The Association Between Maternity Insurance, Residence Status and Selected Perinatal Outcomes Among Chinese Women

Jing (Lexie) Zhang

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The Faculty of Applied Health Science

Brock University

St. Catharines, Ontario, Canada

Jing (Lexie) Zhang ©April 2016

ABSTRACT

Objective: To investigate the impact of maternity insurance and maternal residence on birth outcomes in a Chinese population.

Methods: Secondary data was analyzed from a perinatal cohort study conducted in the Beichen District of the city of Tianjin, China. A total of 2364 pregnant women participated in this study at approximately 12-week gestation upon registration for receiving prenatal care services. After accounting for missing information for relevant variables, a total of 2309 women with single birth were included in this analysis.

Results: A total of 1190 (51.5%) women reported having maternity insurance, and 629 (27.2%) were rural residents. The abnormal birth outcomes were small for gestational age (SGA, n=217 (9.4%)), large for gestational age (LGA, n=248 (10.7%)), birth defect (n=48 (2.1%)) including congenital heart defect (n=32 (1.4%)). In urban areas, having maternal insurance increased the odds of SGA infants (1.32, 95%CI (0.85, 2.04), NS), but decreased the odds of LGA infants (0.92, 95%CI (0.62, 1.36), NS); also decreased the odds of birth defect (0.93, 95%CI (0.37, 2.33), NS), and congenital heart defect (0.65, 95%CI (0.21, 1.99), NS) after adjustment for covariates. In contrast to urban areas, having maternal insurance in rural areas reduced the odds of SGA infants (0.60, 95%CI (0.13, 2.73), NS); but increased the odds of LGA infants (2.16, 95%CI (0.92, 5.04), NS), birth defects (2.48, 95% CI (0.70, 8.80), NS), and congenital heart defect (2.18, 95%CI (0.48, 10.00), NS) after adjustment for the same covariates. Similar results were obtained from Bootstrap methods except that the odds ratio of LGA infants in rural areas for maternal insurance was significant (95%CI (1.13, 4.37)); urban residence was significantly related with lower odds of birth defect (95%CI (0.23, 0.89)) and congenital heart defect (95%CI (0.19, 0.91)).

Conclusions: whether having maternal insurance did have an impact on perinatal outcomes, but the impact of maternal insurance on the perinatal outcomes showed differently between women with urban residence and women with rural residence status. However, it is not clear what are the reason causing the observed differences. Thus, more studies are needed.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ASD: Atrial Septal Defect

BMI: Body Mass Index

CI: Confidence Interval

GCT: Glucose Challenge Test

GDM: Gestational Diabetes Mellitus

ICU: Intensive Care Unit

LGA: Large for Gestational Age

NS: Not Significant

OGTT: Oral Glucose Tolerance Test

ORs: Odds Ratios

PDA: Patent Ductus Arteriosus

SGA: Small for Gestational Age

TOF: Tetralogy of Fallot

TJWCHC: Tianjin Women and Children's Health Center

VSD: Ventricular Septal Defect

WCHC: Women and Children's Health Center

Chapter 1: Introduction

1.1. Preamble

The development of the health insurance industry in China in the past 10 years has introduced several new insurance programs to relieve people's financial concerns, and to integrate with the international insurance markets. Maternity insurance is a newly developed insurance category, which reimburses women, after delivery, to cover fees associated with birth. The development of maternal insurance was initiated by the public's demand for increasing financial security for young parents and childbirth in China. Maternity insurance has become a major demand for insurance pursuers, given the extensive general economic progress for Chinese families since 1990 (Government of China, 2015a).

Economic disparity is defined as how economic metrics (wealth, income, consumption) are distributed among individuals in a group, among groups in a population, or among countries (A three-headed hydra, 2014). It is the most important consideration and contradiction in most developing countries. Rapid urbanization in China during the past two decades has widened the economic gap between urban and rural areas. Compared to urban areas, rural China retains a large population with a lower than average purchase power (Government of China, 2013a). Gini index, a widely used indicator for economic inequality, represents the gap between rich and poor, where 0 represents absolute equality and 1 (or100%) represents absolute inequality (Lee, 1997). The index is defined mathematically based on the Lorenz curve, which plots the cumulative percentages of total income received against the cumulative number of recipients, starting with the poorest individual or household. The Gini index measures the area between the Lorenz curve and a hypothetical line of absolute equality (Lee, 1997). Currently, China has a Gini index of 0.48, which ranks 29th on the list of the world's greatest income inequality between the poor and the rich. As a country, Lesotho ranked number one for the income inequality with Gini index at 0.63, while Sweden is the country of least income inequality with a Gini index of 0.23 (Gap between rich and poor: World income inequality, 2013). Tied to economic status are real and potential impacts on the health of expecting mothers and newborn (Anastasiadis, 2010).

Birth weight is one of the most important health indicators for babies. Birth weight reflects the nutritional status of a fetus during pregnancy, and is associated with a child's future growth and development (Ramuscak, 2010; Hashim et al., 2000). It has been widely accepted that maternal health condition and socioeconomic status have an impact on infant birth weight (Trotter et al., 2010). Unhealthy birth weight as an adverse outcome of pregnancy is linked to severe negative developments in children and adult life (Ramuscak, 2010). Generally, birth weight below the 10th percentile (small-for-gestational-age (SGA), or above the 90th percentile (large- for–gestational- age (LGA) are considered unhealthy birth weights. Unhealthy birth weight increases the risk for fetal mortality, short-term or long-term morbidities. Short-term morbidity would include a rate of administration in Intensive Care Unit (ICU) for the baby after birth (Kramer et al., 1987). Examples of long-term morbidity include cerebral palsy (Chun et al., 2004), mental retardation (Guyer et al., 2009), neurological impairments, and respiratory diseases (Golestan et al., 2012; Eghbalian et al., 2007).

Along with birth weight and subsequent health concerns is the added complication of birth defects. The definition of a birth defect is a series of structural, functional and metabolic disorders at birth or later in life (World Health Organization, 2015a). A birth defect is one of the main causes of infant mortality; it can be single, or multiple occurrences in one or several organs of an infant (Dong et al., 2007). The World Health Organization estimated that congenital disorders occur in 53 per 1000 births in developing countries, compared to 40 to 50 per 1000 live births in developed countries (World Health Organization, 1999). Congenital heart defects are one of the largest groups that make up the congenital malformations. Congenital heart defects occur in 9 out of 1000 newborns globally, which contribute more than 30% of infant mortality (Botto et al., 2003). In China, the incidence of congenital heart defects is approximately 7 to 8 cases per 1000 live births, contributing to 100,000 to 150,000 cases every year (Chinese cardiovascular disease report 2005, 2006), which leads to a huge public health challenge in Chinese society.

Many studies report on the impact of socioeconomic status on birth outcomes. Evidence has suggested that low socioeconomic status leads to an increased risk of adverse pregnancy outcomes (Fujiwara, Ito, & Kawachi, 2013; Kramer, Séguin, Lydon, & Goulet, 2000). In addition, education is the most consistent socioeconomic predictor of an infant's health, whereby lower education significantly predicts unhealthy birth weight (Mahmoodi et al., 2013). Inconsistent results of health insurance or area of residence were observed in previous publications (Hinkle et al., 2014; Kuehan et al., 2007; Xiao et al., 1990), which studied their independent influence on infant birth outcomes (Zhang et al., 2012; Luo st al.,2010; Hanratty, 1996). Most of these studies were in Western civilization. No study has explored the impact of maternal insurance on infant birth outcomes in the Chinese population.

The main purpose of this study was to investigate the impact of maternity insurance and area of residence on infant unhealthy birth weight and birth defects in the Chinese population in Tianjin.

Chapter 2: Literature Review

2.1. Maternal Insurance in China

2.1.1. A Brief History of Chinese Health Insurance

The Chinese health care system has changed rapidly and profoundly since the Chinese Communist party took power in 1949. It is helpful to review the history of Chinese health care system to better understand the Chinese health insurance. In 1949, the new government created a health care system that was owned, by government, and administered similarly in other Communist countries, such as the Soviet Union (Blumenthal & Hsiao, 2015). The health facility's workforce was government-run, such that the government was responsible for all hiring for the health care facilities. There were no insurance companies at this time; the services were mainly free to government employees or extremely cheap to the ordinary citizens. However, the drawbacks to this system were gradually exposed.

By 1984, the Chinese health care system was turned into a free-market reorganization as an afterthought related to the rest of China's economy. The Chinese government reduced its direct role in all economic and social sectors, including health care. As a result while the government still owned the hospitals but it had less control over the health care organizations. In order to make China's experiment with free-market health care more dramatic, the government withdrew coverage for health expenses in 1994 (Blumenthal & Hsiao, 2015). To quickly address the increased health related expense to citizens, a new health insurance system managed by insurance companies was introduced which reimbursed health related medical expenses to its clients (Blumenthal & Hsiao, 2015). The government used several coastal urban cities for a pilot trial with two new organizations government and civil medical insurance institutions and urban employee medical insurance institutions. Government and civil medical insurance institutions cover government and civil employees, and the urban employee medical insurance institutions deal with company employees in urban areas (Blumenthal & Hsiao, 2015).

By 1998, based on the experience of the pilot trial, the Chinese government extended the package that worked in these selected coastal cities to the entire country. During the same time period, the free-market reforms resulted in public anger and distrust toward the health care organizations and medical workers, as demonstrated by intensive physical attacks on physicians (Blumenthal & Hsiao, 2015). Dissatisfaction with the lack of access to health care, especially for the people living in rural areas, and expensive hospital services drove many patients into poverty (Blumenthal & Hsiao, 2015). As a response, the Chinese government took a step in 2003 to mitigate popular discontent with health care by introducing a new health insurance strategy- rural cooperative medical insurance institution to cover some hospital expenses for rural residents (Government of China, 2012a). In 2007, in order to benefit all the urban residents, the government introduced urban residents' medical insurance to deal with retirees or those living in urban areas without a stable income (Government of China, 2012b). In summary there were four variations of health coverage: the Government and Civil Workers Insurance Institution, Urban Employee Insurance Institution, the Rural Cooperative Medical Insurance Institution and the Urban Residents Medical Insurance Institution.

The government and civil worker medical insurance is predominantly paid by the government, and covers most of the medical expenses excluding nutrition and cosmetic surgery expenses such as ginseng. The Urban Employees' medical insurance fees are covered by both the employees (i.e., employees pay 2% of their salary) and the employers (i.e., employers pay 7% of the employees' salary). The Rural Cooperative medical insurance fees are paid mainly by the citizens themselves with very limited subsidy from the government. The Urban Residents medical insurance fees are usually paid by the citizens themselves with limited subsidy from the government. These insurances only cover hospital visits, prescription drugs, and in-hospital treatment within the scope of basic health insurance provisions (Government of China, 2012a).

2.1.2. Maternal Insurance and Its Current Situation

To better understand maternity insurance, it is first important to understand the fundamentals of insurance. Insurance is designed on the concept of "pooling of risk" to protect against financial losses caused by unpredicted accidents in a person's life (Fischer, 1975). Statistically speaking, the probability of such accidents can be predicted using a population- based group on which insurance carriers can spread the financial burden of risks from an individual level to a population level (Fischer, 1975).

There are two types of maternal insurances in China: social maternal insurance and commercial maternal insurance. According to the official Chinese maternal insurance provision, all of the social maternal insurance fees are paid by a legal company for any pregnant woman who establishes an employment relationship with this organization and complies with the one child policy. The insurance covers expenses related to pregnancy for an employed woman, but not for an unemployed woman. In general, it covers each doctor visit and laboratory tests in prenatal care services, such as blood and urine tests, ultrasound examination, and the expenses related to fetus delivery, which includes hospitalization and/or operation if necessary (e.g., cesarean section). Pregnant women are recommended to have approximately 10 prenatal doctor visits during their pregnancy, which are scheduled at the 12^{th}, between the 13^{th} and the 16^{th}, the 17^{th} and the 20^{th}, the 21^{th} and the 24^{th}, the 25^{th} and the 28^{th}, the 29^{th} and the 32^{th}, the 33^{th} and the 35^{th}, at the 36^{th}, the 37^{th}, and the 38^{th} gestational weeks (Government of China, 2015b). Even after the pregnant woman is discharged from hospital, certain diseases as a result of the pregnancy are also paid by the social maternal insurance, however the coverage time period and percentage are not specified in the policy. In addition, the insurance is supposed to cover the average monthly wage that the pregnant woman could get from her company when she is off work (Government of China, 2015c). Unemployed women have to pay all the maternal insurance fees themselves if they want it without the benefit of pregnancy allowance, so in reality, unemployed women usually do not have maternal insurance.

However, the real situation may differ from the official provision in each province. According to the Tianjin maternal insurance policy, social maternal insurance fees are paid mostly by a legal enterprise for any pregnant woman who establishes an employment relationship with this enterprise, and complies with the one child policy; the pregnant woman need to pay a small portion of this maternal insurance herself. In addition, the maximum limits of benefit coverage differ within the maternal insurance. For instance, the maximum benefit for doctor visits fees paid by insurance company is $212 (CDN currency); Maximum benefit for delivery fee paid by insurance company for natural birth is $577 (CDN currency); maximum benefit for delivery fee paid by insurance company for intervention birth is $596 (CDN currency); maximum benefit for surgery fee paid by insurance company for simple caesarean section is $692 (CDN currency); maximum benefit for surgery fee paid by insurance company for complicated caesarean section with myomectomy, or ovarian cysts is $731 (CDN currency). The out of pocket costs such as multiple supplements, additional doctor visits if needed have to be paid by the pregnant women themselves. Part of the treatment fee for certain diseases caused by birth can be paid by maternal insurance, but there is also a maximum limit amount according to the severity and variety of the diseases. Pregnancy allowance is paid by the company according to individual provisions within the company regarding the amount and duration of payment (Government of China, 2014a).

Commercial maternal insurance primarily protects mother and child from any unexpected accidents or risks during pregnancy or labor, including maternal abnormality, neonatal death and infant congenital disability. Commercial maternal insurance does not cover any costs related to doctor visits, natural birth or cesarean section delivery (Government of China, 2014b). However, commercial maternal insurance purchase is very low in China as there are very few insurance companies providing the service, and the price for this insurance is high. Most people feel it is unnecessary to buy commercial maternal insurance when they are covered by social maternal insurance, which is much cheaper than commercial insurance. Therefore the maternal insurance in this study refers to social maternal insurance (Table 1).

Table 1 Maternal insurance type in China

	Social maternal insurance	Commercial maternal insurance
Payments	Mostly paid by the employers	Paid all by the insurant
Benefiter	Currently employed pregnant women	Any pregnant women
Items covered	Doctor visits, natural delivery, caesarean section delivery, part of treatment fees	Maternal abnormality, neonatal death, infant disability

Unlike Canada and other western countries, China does not have a universal health care system that covers basic medical related treatment. Furthermore, one child per family is still the main family policy (rural residence can have more than one child) (Government of China, 2015d). In addition, cesarean section delivery is very popular among current Chinese women influenced by cultural beliefs. The World Health Organization reported that over half of Chinese pregnant women chose to have cesarean section delivery. Chinese and some Asian countries are influenced by many superstitious concepts believing that it is important to pick an “excellent” day to bring their children to this world, thus cesarean section is their best approach to accomplish this goal. Some doing so are simply to avoid painfulness during labors, and some mistakenly believe that cesarean is safer than natural birth (World Health Organization, 2008).

The most fertile population is young couples who tend to be limited financially. Therefore young married couples usually purchase social maternity insurance to cover costs associated with childbirth, and to ensure adequate health care for the pregnant women and infants at a relatively reasonable cost. Pregnancy and childbearing are at risk for complications such as cesarean section, hypertensive disorders of pregnancy, premature separation of the placenta, unexpected major bleeding, and hemorrhage. Mothers and infants require more financial and physical protection, and the insurance can cover the costs for essential medical events. According to the average expenses during pregnancy, the doctor visits fees are around $250 (CDN currency); natural delivery fee is around $385 (CDN currency); caesarean section fee is between $960 and $1346 (CDN currency) (Government of China, 2013b). Therefore, reimbursement from maternal insurance can cover most expenses for doctor visits, nature birth and about half of caesarean section surgery fee.

2.1.3. The Characteristics of Women Who Have Maternal Insurance

The average female education level in China was middle school graduate reported by the sixth demographic census in 2010 (Yang & Xie, 2010). The pregnant women who have social maternal insurance are likely to be more educated than pregnant women without maternal insurance. The Chinese population's education level improved nationally in the past 20 years. According to a survey conducted in 2010, roughly 142 million people were receiving higher education (more than high school), composing 10.5% of all population (Government of China, 2015d). As described previously, the pregnant women who have social maternal insurance are currently employed, which implies a relatively higher education level. Schwartz (1990), reported similar characteristics of women with commercial health insurance who were more likely to be married and had graduated from high school than women without health insurance.

Most of the women with maternal insurance are living in urban areas. Women living in rural areas are usually engaged in agriculture work, which means they are self-employed. If those women want to have social maternal insurance, they have to pay all of the insurance fees on their own. In reality, most pregnant women in rural areas do not buy any maternal insurance due to the limited income from farming work.

The Chinese views toward family, marriage, and childbirth have changed profoundly over the years. Presently, mature marriage and the quality of childbirth are more important than the former expectations of a traditional early marriage and several children. In 1970 the average age of women at marriage was approximately 20.2 years old, but in 2007 it was 24.9 years of age (Government of China, 2015d). This is highlighted by the fact that women with maternal insurance are generally older than women without maternal insurance (Schwartz, 1990). Many women spend their early lifetime pursuing higher education to ensure better life quality for their future families. Women tend to marry later than previous generations with a greater sense of responsibility toward their children and family; and being more knowledgeable, better prepared to fulfill the two important roles in a family constitution that of mother and wife (Lee, 2009).

2.2. Residence Policy in China

2.2.1. History of Chinese Residence

Huji household registration is a certificate offered by the government in charge of the household affairs, which has a record of citizen's basic information, such as name, date of birth, marriage status, relatives, place of birth etc. Household registration policy dictates citizens' legal identity in China and legitimacy of living in particular local areas. Every legal Chinese citizen is registered in the Public Security Bureau in the geographic area at birth (Government of China, 2015e). "Huji" is a Chinese word. "Hu" in Chinese means "each family" and "Ji" means "record", so "Huji" general means "family record". China has a long history of Huji registration, which began as far back as the Chunqiu dynasty (B.C. 476 years). Since 1949, the Chinese government, led by the Communist Party, had gradually reformed the policy. Prior to 1958 Chinese citizens were free to move, without limitations, between urban areas and rural areas. Since 1958, China implemented a "strict Huji" household registration policy to control urban and rural migration (Government of China, 2015e). Based on the relationship between geography and family members in the Chinese household registration system, the Chinese population is divided into agricultural and non-agricultural households to prevent migration between urban and rural areas. However, Huji residence can only represent one's original place of birth and the person's possible upbringing. Urban Huji residents seldom move to rural areas, but many rural Huji residents may move to urban areas temporarily for job opportunity still maintaining a rural Huji residence. Therefore, the "rural residence" may not truly indicate that the pregnant women are currently living in rural locations, although the majority of women with rural residence are living in the rural areas. This policy caused widespread controversy and accusations of liberty. Initially Huji policy strictly limited farmers migrating into cities, and inter-city migration as a means to better control and manage people. As a result, the system has built urban and rural isolation and inequality.

2.2.2. Current Chinese Residence Policy

After 1978, the Huji policy has been modified with allowance of farmers working and living in the cities temporarily, but still denied their access to government provided services reserved for city residents such as children's education, health care service, formal-sector jobs and social benefits.

Children who move with their parents from rural areas to urban areas with temporary residence status have to pay an additional school fee and are always denied access to elite schools. It is estimated that as a result, 14-20 million migrant children are lacking in education. The dropout rate from primary schools and secondary schools for the migrant children exceed 9%, as opposed to nearly 0% for local urban children (Palgrave et al., 2009). Access to health services is restricted for them as well. In Shanghai, which is known as one of the best cities in China for providing social services to migrants, only two thirds of migrant children were vaccinated in 2004, compared to universal vaccine rate for local urban children (Palgrave et al., 2009). Many migrants remain marginalized in destination places because of governmental policies. They have fewer channels and opportunities to protect their rights in the working place. In addition, migrant workers tend to work in informal jobs without adequate benefits. Surveys have suggested that about 75 % of the 11,000 fatalities in 2005 in the most dangerous mining and construction industries were migrants. Migrant workers usually work 50 % longer hours than local workers, and are typically hired without a written contract or without a health insurance (Palgrave et al., 2009).

A second-tier migration policy was recently designed that allows a migrant person to change their status to permanent residency, presuming they are well-educated rural migrants, but only permits temporary residency for less-educated rural migrants. Some city governments offer “blue-stamp” Huji to rural migrants who can provide marketable investments in the urban areas. The social and economic value of proper registration means that the unregistered citizens encounter great difficulty in accessing education, employment, and health care (Chinese Huji Institution, 2011).

Huji household registration clearly outlines the differences between people with rural or urban residence status and will be used in this study as the definitions of urban and rural residence.

2.2.3. Difference Between Urban and Rural Residence

According to the Huji registration, China is the largest agricultural country in the world with almost 60% of the population living in rural areas across the country (Huji, 2014).

However, rural-city commuting is poor. There are three possible reasons contributing to the urban and rural differences in China. First, Huji household registration policy limits the movement of people, in particular rural residents, and their accessibility to education and health care. Second, limited transportation facilities in rural areas and crowded traffic conditions in urban areas impact ease of commuting; thirdly lower government investment in rural areas as opposed to urban areas results in unbalanced economic development between urban and rural areas. Urban-rural disparities in China are demonstrated mainly in education investment, health care and income.

2.2.3a. Education Investment Disparity by the Government

Education investment has two components: teaching facilities and teacher resources. Despite recent developments in the Chinese education system, there are still many unresolved issues. Education investments are primarily government funded with provincial investment support, as well as contributions from social sponsors or personal sponsors. Government managed schools are predominantly funded by the government, and are usually located in large urban areas. Province managed schools are mainly funded by the province, and are usually located in second-tier cities, the small cities around capital city in each province. Schools in rural areas are funded by sponsors with limited subsidy from the government. There is a significant education investment disparity between urban and rural areas. The Chinese government invests in a few key schools in metropolitan regions, and gives little or no help to most of the schools in rural areas (Peng, 2012). It is reported that between 1990 and 2000, almost half of the rural schools were close due to lack of funds, teachers, and sufficient enrollment of students. From 2000 to 2010 the student population in rural elementary schools dropped from 550,000 to 260,000, an average of 56 schools closed per day (Song, 2014).

A substantial amount of data has supported evidence of the significant difference between urban and rural schools education investment. The schools in urban areas usually have better teaching facilities, with libraries, computers, advanced labs and multiple sports grounds, which are rare to nonexistent in rural schools (Song, 2014). Highly qualified teachers are not willing to teach in rural areas, considering these areas offer low income and poor living conditions compared to work at an urban school. This has further prevented rural schools from attracting experienced teachers and achieving higher quality education (Song, 2014).

Education level is the main difference between urban and rural residents that is associated with pregnant women's maternal insurance status and a potential explanation for urban rural disparity on perinatal outcomes.

2.2.3b. Health Care Disparity

The health care system in China has two major drawbacks. First, the health insurance system is not universal. It was reported that 66% of citizens do not have any form of health insurance; 65% of all medical expenses are entirely the responsibility of the citizens; 25% of the urban and rural patients have declined treatments because of their inability to pay for the medical expense. In 2005, the health minister of China pointed out in a report that 50 million civil servants had free medical care. The medically insured urban employers numbered 130 million, but less than 2 million urban residents had medical insurance and the number of people who had rural cooperative medical insurance was only 170 million, less than a quarter of all 800 million rural residents. The government's financial support for health care for rural residents is also very limited at approximately 30 dollars per person (Yang, 2007).

The insufficient government investment in Chinese health care, particularly in rural areas presents the second problem. As hospital location is predominantly dictated by the economic status of the region, metropolitan regions account for approximately 80% of all hospitals leaving the less affluent countryside with limited hospital access. It was reported that the national medical expense in 2006 was $182.3 (CDN currency) billion in total; roughly $121.9 billion or 66.9% (CDN currency) were accounted for by urban areas, while rural areas received $60.4 billion (CDN currency), or only 33.1% of the total funding costs (Bai & Cui, 2011).

Rural residential areas are facing challenges with the lack of advanced medical technology, qualified medical workers, optimum hygienic conditions, and sufficient medical products (Song, 2014). The Government of China has extended great effort into improving the health conditions in rural areas in the past few decades, however the disparity between urban and rural areas has not significantly declined (Cheng & Lu, 2009; Wu & Liu, 2004). In 1999, the infant mortality rate in the province of Anhui was 45.9 per 1000. This is also one of the poorest provinces of China. In contrast, the infant mortality rate was only 3.5 per 1000 in Shanghai (Cheng & Lu, 2009; Wu & Liu, 2004). In general, most of these causes of infants' deaths are preventable or treatable if the treatment was administered in a timely manner and if access to health services and preventative health clinics in China was not dependent on the wealth of the regions. For instance: village or neighborhood health clinics provide very basic and preventative care services; township or sub-district health centers are staffed by primary care physicians and give more advanced outpatient services but have few beds to allow extended observation of patients who are not seriously ill; city hospitals can provide specialty care and inpatient services more readily (Blumenthal & Hsiao, 2015). Most of the medical resources and government investments are clustered in larger cities and capital cities, therefore people living in rural areas have to travel a great distance to seek medical attention for complicated diseases.

2.2.3c. Income Disparity

From 1970 to 2010, the Chinese economy experienced an abrupt increase. The average urban monthly income increased 60.7 times from $58 to $3,539 (CDN currency), while the average rural monthly income increased 56.6 times from $21 to $1183 (CDN currency) (Song, 2014). Although both urban and rural income increased significantly, the extent of economic growth in urban areas surpassed that of the rural areas. In China, the urban population consists of less than 50% of the total population, however this population accounts for 87% of the social fixed asset investment and a large portion of this social fixed asset investment is accounted for in the metropolitan areas. It is important to understand the financial differences between urban and rural populations to further highlight to the government the issues around and lobby for infant health improvement.

2.2.4. Comparison to India

Using India as a comparable county to Chinese health care system and residence. The Ministry of Health in India was created by the time of independence from Britain in 1947, and then made a series of a five year plan to make health a priority. The national Health Policy was established in 1983, which aimed to reach universal health care coverage by the time of 2000, and was updated in 2002. The health care system in India is predominantly administrated by the state. Each state offers health care services for its people. Indian citizens have free movement to migrate from rural regions to urban regions. However, there is a great disparity in the quality and coverage of medical treatment in India between states, urban, rural residents. Rural residents are suffering from a great deal of physician shortage, poor hygiene conditions, less hospital access, and rural residence from the poorest state like Bihar is the one that suffer the most (Healthcare system In India, 2015). In India there are public and private health care sectors. Poor quality of public health care sectors, such as long distance of health provider, long waiting time period and inconvenient hours of operation, is the main reason that many people chose to go to private health care sectors (Health in India, 2015). To help pay for the health care costs, Indians can buy health insurance, often provided by employers, but similar to China, most people lack health insurance, and a big portion of health expense has to be paid out of pocket (Laxmi Narayan, 2011).

2.3. Selected Adverse Perinatal Outcomes

Perinatal outcomes refer to the outcomes that take place in the period immediately before and after birth. However, the definition of the perinatal period varies in several ways. It commences at 22 completed weeks (154 days) of gestation and ends seven completed days after birth according to the WHO definition (World Health Organization, 2015b). Adverse perinatal outcomes include preterm birth, stillbirth, infant mortality, unhealthy birth weight, birth defects, ICU, neonatal intraventricular hemorrhage, and respiratory distress syndrome (Ramuscak, 2010; Timby & Smith, 2005). In this study, attention will be drawn to unhealthy birth weight and birth defects. Unhealthy birth weight and birth defects are associated with infant early mortality; affect infant growth during adolescence period and even trigger adult diseases (Ramuscak, 2010).

2.3.1. Unhealthy Birth Weight

According to the World Health Organization, extreme low birth weight is considered as the birth weight less than 2500g, and extreme high birth weight is considered as the birth weight larger than 4500g (World Health Organization, 2004). Birth weight is determined by two factors for a singleton normal fetus, duration of gestational age (preterm birth), and the rate of prenatal fetal growth. Prenatal fetal growth refers to the expected weight of a fetus at a given gestational age (Ramuscak, 2010).

2.3.1a. Small for Gestational Age

Low birth weight occurs when there is a premature birth before 37 weeks, or there is an intrauterine growth restriction. These infants with an intrauterine growth restriction that lie below 10th percentile for that gestational age are known as small for gestational age (SGA) infants, who are at increased risk for fetal mortality, short-term and/or long-term morbidities (Ramuscak, 2010). Some examples of short-term morbidities are sudden death syndrome, and complications due to hospitalization (Kramer et al., 1987). Some examples of infant long-term morbidity are cerebral palsy (Chun et al., 2004), cognitive limitations (Guyer et al., 2009), incidence of neurological impairments, and respiratory diseases (Golestan et al., 2012; Eghbalian et al., 2007). Furthermore, SGA babies require additional medical and financial supports from the family or government in order to increase survival rate and achieve overall health (Russel et al., 2007; Reime et al., 2006; Frisbie et al., 1996).

2.3.1b. Large For Gestational Age

High birth weight can occur when infants are born later than 42 weeks after conception, or have a higher prenatal growth rate. An infant's weight with higher prenatal growth rate that lies above the 90th percentile for that gestational age is referred to as large for gestational age (LGA) (Ramuscak, 2010). LGA negatively affects both the infant and mother's health and morbidity. LGA infants have a higher risk of developing respiratory issues, shoulder dystocia, brachial plexus palsy (Timby & Smith, 2005) and neonatal adiposity (Tikellis et al., 2012). Studies have demonstrated that a high birth weight contributes to a significant amount of the variance (41%) in neonatal adiposity status (Tikellis et al., 2012). Neonatal adiposity further increases the risk of cardiovascular disease later in development, development of type 1 diabetes in childhood, and rheumatoid arthritis (Cardwell et al., 2010; Mandl et al., 2009). Mothers of LGA babies have greater risk for caesarean delivery with therefore higher medical expense (Jolly et al., 2003; Rouse et al., 1996).

Regardless of the type of unhealthy birth weight, there is an increased demand for medical support, and subsequently an increased cost to treat the adverse outcomes following the pregnancy period. From a public health standpoint, mean birth weight is a useful criterion for monitoring a mother's condition, as well as the multiple support systems from society and families. Mean birth weight of the infants indicates pregnant women are receiving regular prenatal examinations, adequate nutrition supports, moderate social stress and other psychosocial supports from the family members (Ohlsson et al., 2008; Kliegman et al., 2007). Many studies investigated the impact of health insurance on both low and high birth weight, however few studies have explored the association between health insurance and SGA or LGA. Furthermore, studies focusing on the impact of health insurance on SGA and LGA have been inconsistent (Hinkle et al., 2014; Schwartz, 1990). A previous study by Norton indicated that the increasing prevalence of intrauterine growth restriction contributed to most of the differences between developed and developing countries in low birth weight rate (Norton, 1994). In developing countries intrauterine growth restriction contributed to the majority of the low birth weight, while preterm birth were the predominant cases for low birth weight in developed countries (Table 2) (Norton, 1994). Therefore, in the current study, SGA and LGA are used as the main perinatal outcomes.

Table 2 Incidence of low birth weight (<2500 g) in developing and developed areas

	Populations from developing countries	Populations from developed countries
Number of populations studied	60.0	16.0
Total low birth weight (%, average)	17.3	5.2
Pre-term/low birth weight (%, average)	5.9	3.1
IUGR/low birth weight (%, average)	11.5	2.0

Note. Reprinted from "Maternal nutrition during pregnancy as it affects infant growth, development and health," by R. Norton, 1994, *SCN News / United Nations, Administrative Committee on Coordination, Subcommittee on Nutrition*, 11, 10-4.

2.3.2. Birth Defects

The definition of a birth defect is a series of structural, functional and metabolic disorders after birth. Risk factors leading to birth defects include: genetics, chemical exposure, physical and biological issues and maternal conditions. More than half of the defects are caused by multiple factors (Wilson et al., 1997).

2.3.2a. Congenital Heart Defect

Congenital heart defect is a defect in the structure of the heart and great vessels, present at birth. There are many types of congenital heart defects, and most of them have either obstructed blood flow in the heart or nearby vessels, or the congenital heart defect causes the blood to flow through the heart in an abnormal pattern (Description of congenital heart defects, 2013). In the United States, congenital heart defect (CHD) is the most common birth defect and the main cause of infant deaths. In China, the incidence of congenital heart defects is approximately 7 to 8 cases per 1000 live births, contributing to 100,000 to 150,000 cases every year (Chinese cardiovascular disease report 2005, 2006), which leads to a huge public health challenge in Chinese society. Even though peri-surgical management has reduced infant mortality in the past few decades, congenital heart defect still accounts for almost 29% of all deaths related to congenital malformations and 5.7% of all infant deaths (National perinatal statistics, 2002). Extensive publications have reported that socioeconomic factors play crucial roles in the development of congenital heart defect (Peiris et al., 2009; Williams et al., 1995). It has been suggested that socioeconomic status is the most important factor affecting health (Williams et al., 1995). Congenital heart defect was also a health problem worldwide. Comprehensive studies in different populations with various methods would add more knowledge to the existing literature to help us better understand its etiology.

2.4. Maternal Insurance's Impact on Selected Perinatal Outcomes

2.4.1. Insurance's Impact on Unhealthy Birth Weight

Many countries like United Kingdom with free health care and United States with national health insurance to cover essential basic expenses related to health care. There are debates about how national health insurance affects people's health status in the population level. Some argued that national health insurance improved the population's health because it shifted resources from over-served populations to under-served populations, and it also benefitted people who could not receive medical care due to financial constraints (Hanratty, 1996). Another point of discussion was that national health insurance shifted from curative treatment to preventative care. Others complained that national health insurance reduced the quality of health care, and significantly prolonged the wait time for high-tech medical services (Hanratty, 1996).

Using Canada as an example, studies in selected Canadian cities found that both the infant care and care for the economically disadvantaged communities improved substantially after the introduction of national health insurance (Hanratty, 1996). In a study by Hanratty (1996), natural experiment as a means to measure the impact of national health insurance on the infant health by comparing changes in provinces that implemented national health insurance. There was evidence from local studies on the percentage of pregnant women and infants who received prenatal and infant care before and after the implementation of Quebec's national health insurance (Table 3) (Hanratty, 1996). From the table, we can see that the increase in doctor visits and post pregnancy checkups was substantial in families with income less than $5,000 (CDN currency). The percentage receiving prenatal care in the first trimester increased from 27% to 56%, and the percentage receiving care in their first month increased from 73% to 94%. These results suggested that a marked change in health care utility had been introduced into Canadian society over a short time after the introduction of national health insurance (Hanratty, 1996). From the year of 1960 to 1975, it was found that a 4% decrease in infant mortality rate in Canada was associated with the introduction of national health insurance. Similar outcomes were reported regarding the incidence of low birth weight in infants. From 1960 to 1974, the incidence of low birth weight dropped by an average of 1.3% for the total population, and 8.9% for single parent families. This result also suggested that most of the decline in infant mortality came from the decline in infant low birth weight specific mortality rate, other than just a decline in infant low birth weight (Hanratty, 1996).

Table 3 Prenatal and postnatal doctor visit before and after national health insurance in Montreal

	Family income			
Adequacy of perinatal and postnatal care	Less than $5,000	$5,000 to $8,999	Over $9,000	All pregnant women
Percent with doctor visit in first trimester:				
1969-70	26.6	45.0	49.2	40.9
1971-72	56.3	52.8	53.8	54.9
Change:	29.7*	7.8	4.6	14.0*
Percent with doctor visit in first months:				
1969-70	73.4	86.7	88.9	82.5
1971-72	93.8	89.9	95.0	92.6
Change:	20.4*	3.2	6.1	10.1*
Percent of women with check-up after pregnancy:				
1969-70	64.6	63.3	75.4	66.0
1971-72	78.1	73.0	86.3	79.5
Change:	13.5	9.7	10.9	13.5*
Percent of infants with exam after return home:				
1969-70	70.8	82.4	88.5	79.2
1971-72	78.1	81.2	90.7	85.0
Change:	7.3	-1.2	2.2	5.8
Sample size:				
1969-70	65.0	121.0	64.0	272.0
1971-72	32.0	89.0	89.0	215.0

Notes: Dollar amounts are in 1971 Canadian dollars. The corresponding 1993 U.S. dollar thresholds for $5,000 and $9,000 are $15,700 and $28,200 respectively. Infant exams after return home are based on live-births only. Data are from Alison D. McDonald et al. (1974).

*Indicates that change is significantly different from zero at 5-percent confidence level.

Note. Reprinted from "Canadian national health insurance and infant health," by M. J. Hanratty, 1996, *American Economic Review*, 86(1), 276–284.

There are papers that have reported on the impact of health insurance on infant with low birth weight. However, health insurance is also considered an inconsistent factor across these studies. A study by Schwartz from Arizona in United States reported that pregnant women without commercial medical insurance had significantly higher proportions of low birth weight births than the women with commercial health insurance. The same study also reported that women without insurance were younger, more likely to have a parity of three or more; they were more likely to be unmarried when delivering infants, and tended to be less educated than the women with commercial insurance. A significant difference regarding the women themselves and their infants, could be attributed to the fact that women with commercial insurance were wealthier compared to other groups (Schwartz, 1990). In a hospital-based cohort study by Hinkle in the US, when comparing public health insurance to private health insurance, public health insurance was associated with an unadjusted increased percentage of incidence and recurrence of small for gestational age cases. However, public health insurance was no longer associated with recurrence or incidence of small for gestational age once adjusted for mother's demographics and medical conditions (Hinkle et al., 2014). Thus health insurance affects pregnant women with a greater risk of poor perinatal outcome with inconsistent reports.

2.4.2. Impact of Maternity Insurance on Birth Defects

Recently a study in the United States have shown that medical insurance, race, and socioeconomic position are independently related to disparities in the medical use of common technologies, procedures and emerging therapies (Jha et al., 2005). A study of the association of socioeconomic position and medical insurance with fetal diagnosis of critical congenital heart defect, found that the higher socioeconomic group had a lower proportion of individuals living below the federally defined poverty level, and higher opportunity of having private insurance. In the univariate analysis, infants whose mothers had private insurance were more likely to have pre-diagnosis of congenital heart defect. Similarly, infants whose mothers were in a higher socioeconomic position tended to have pre-diagnosis of congenital heart defect. Higher socioeconomic position was associated with higher chance of purchasing private insurance, which was further associated with higher chance of having a pre-diagnosis of congenital heart defect (Peiris et al., 2009). Pre-diagnosis can be important to a child health. Children with pre-diagnosis have better prognosis if early treatment is performed than the children with late treatment until they start to show a symptom of a birth defect. Nowadays, new technology can even fix certain birth defect during pregnancy period if a pre-diagnosis is made (Cuneo et al., 2003). Inequities in treatment are known to exist in the access to advanced technology and innovative medical services. And the ability to access highly elective therapies is correlated to the type of insurance coverage that patients purchase (Finkelstein et al., 1998).

2.5. Impact of Residence on Selected Birth Outcomes

2.5.1. Impact of Residence on Unhealthy Birth Weight

Several papers have reported that the place of residence has an impact on infants' birth outcomes. A study in Manitoba Canada exploring infant birth outcomes by the degree of rural isolation among First nations and Non-First nations found that both First Nations and Non-First Nations had a 15-20% lower rate of preterm birth, SGA, and LBW birth in rural areas than in urban areas. After controlling for different observed maternal characteristics such as maternity age, marital status, parity, infant sex, and plurality, the risk of preterm birth, SGA, or LBW birth in rural versus urban areas remained significantly lower for both First Nations and Non-First Nations. For the non-First Nations, there was a significantly higher rate of LGA and high-birth-weight birth in more isolated areas (Luo et al., 2010). Similarly, a study from Poland reported that urban residences were at greater risk of delivering an SGA baby (Hanke, Kalinka, & Sobala, 1998).

A series of studies on relationship of degree of isolation on birth outcomes identified a trend that residence in rural areas, regardless of the degree of isolation, had a protective effect against SGA or low birth weight (Luo et al., 2008; Hillemeier et al., 2007). In contrast, a study from New York reported that SGA is not consistently associated with different definitions of residence typologies (Strutz et al., 2012). More studies are still needed to evaluate the association between maternal residence and infant birth weight.

2.5.2. Residence's Impact on Birth Defects

A study conducted in Inner Mongolia, China, investigated the relationship between living places and birth defects, such as anencephaly, spina bifida, encephalocele, congenital heart disease, total cleft lip, polydactyly, congenital hydrocephaly, external ear malformation, limb reduction, inguinal hernia, congenital hemangiomas among others. The study found that the overall prevalence of birth defects was 156.1 per 10000 births (95% CI=146.3-165.8); 124.6 per 10000 births (95% CI=111.1-138.1) in urban areas compared to 179.4 per 10000 live birth (95% CI=165.5-193.3) in rural areas ($p<0.05$). Relative risk was 1.78(95% CI=1.68-1.88) indicating that living areas had significant association with birth defects (Zhang et al., 2012).

Out of all the birth defects in China, central nervous system issues held the highest proportion of birth defects (19.8%), followed by face or eye defects (18.0%), then cardiovascular defects at 12.4% (Zhang et al., 2012). Neural tube defects containing anencephaly, spina bifida, hydranencephaly and encephalocele are the most common structural defects of the central nervous system. Many epidemiologists have noticed the geographic variation in neural tube defects, and studies across the world demonstrated geographic difference. A study from United State reported that central nervous system defects were observed to be more prevalent in urban areas than rural areas (Kuehan et al., 2007). Another study conducted in China found an urban-rural difference in the risk factor of neural tube defects with a higher risk in rural areas (Xiao et al., 1990). A report from Texas, United States studied separate analysis showing that no urban –rural difference was demonstrated in the rate of anencephaly or spina bifida without anencephaly in adjusted or unadjusted analysis, while encephalocele was higher in more suburban areas (Luben et al., 2009). In contrast, one study from New Zealand reported no difference regarding the risk factor of neural tube defects (Borman et al., 1993). However, agricultural factors can support that central nervous system defects are more prevalent in rural areas. A significant number of studies have shown that when both mother and father are engaged in agricultural work, there is an increased risk for an infant to be born with neural tube defects (Blatter et al., 1994).

Cleft lip with or without cleft palate is also a common birth defect, which occurs in 5 to 18 cases out of 1000 births (Larsen et al., 1993). Amidei et al in Colorado found that residence in rural geographic regions was associated with higher propensity of orofacial clefts, and non-metropolitan regions were associated with higher propensity of any oral cleft defects at birth (Amidei et al., 1994). Similarly, factors like agriculture work conditions, or the use of pesticides have been found to correlate with increased odds of clefts defects (Romitti et al., 2007). In summary the results from multiple studies on the relationship of residence and birth defect are not consistent and vary by diseases.

2.5.3. Impact of Residence on Congenital Heart Defect

The comprehensive etiology of congenital heart defect is not well understood. Even though researchers have noticed that the geographic factor has contributed to congenital heart defect, the results are not consistent. Studies showed that rural areas have a higher rate of general congenital heart defect than urban areas, yet other papers showed no difference (Cedergren et al., 2002; Tikkanen et al., 1991).

Varying factors also indicated different results in terms of which areas have increased risk of developing congenital heart defect, or no impact at all. Maternal occupations in agriculture or fishing were considered to increase the risk of congenital heart defect (Chia et al., 2004). Pesticide was noted in two studies to be associated with the prevalence of congenital heart defect and its subgroup -conotruncal defect (Shaw et al., 1999; Garry et al., 1996) or no association (Tikkanen et al., 1991). Studies had reported that the risk of conotruncal defect and other cardiac anomalies increased with increasing road traffic density (Cordier et al., 2004), and air pollution was linked to specific heart defect in urban areas (Ritz et al., 2002).

Specific subgroups of defects within congenital heart defect may demonstrate urban and rural differences. For example, conotruncal heart defect with normally related great arteries was seen to be significantly higher in urban areas versus rural areas, but no difference between rural and urban areas was observed in conotruncal defects with transposed arteries (Ferencz et al., 1997). While another study in Texas illustrated that Tetralogy of Fallot (TOF), a subgroup of conotruncal defect, was more prevalent in rural residence with cropland exposure (Langlois, 2010).

In examining the congenital heart defect mortality, specifically in China, one study reported that the pattern was changing significantly when comparing urban mortality to rural mortality over time. Although most congenital heart defect-related deaths occur in younger patients, less than 1 year of age, the pattern started to change from 2003 to 2010. Females living in urban areas had increasing congenital heart defect mortality rate over time, while females living in rural areas had a slight drop in congenital heart defect mortality (Hu, Yuan, Rao, Zheng, & Hu, 2014). In summary, urban or rural residence show inconsistent association with the prevalence of congenital heart defect with different explanations.

2.6. Other Factors that Are Related to Selected Birth Outcomes

Past researches have already found other determinants strongly related to birth weight and birth defect that generally could be divided into maternal demographic factors, physical factors and genetic and environmental factors (Table 4).

Table 4 Other factors that are related to selected birth outcomes

Factors/Outcomes	Birth weight		Birth defect	
Sex	✔	Alberico et al., 2014; Tikellis et al., 2012		
Maternal age	✔	Machado, 2006		Zhang et al., 2012; Patel & Burns, 2013
Maternal education	✔	Mahmoodi et al., 2013	✔	Zhang et al., 2012
Maternal household income	✔	Mahmoodi et al., 2013	✔	Yang et al., 2008
Marital status	✔	Verropoulou & Basten, 2014		
Multiple birth	✔	Verropoulou & Basten, 2014		
Multiparity	✔	Alberico et al., 2014; Park et al., 2011	✔	Feng et al., 2014
Multiple pregnancies			✔	Zhang, Olshan, & Cai, 1994; Feng et al., 2014; Zhang et al., 2012
Pre-pregnancy BMI	✔	Li et al., 2013; Ferraro et al., 2012	✔	Patel & Burns, 2013
Excessive gestational weight gain	✔	Li et al., 2013; Ferraro et al., 2012		
Mothers with gestational diabetes mellitus	✔	Alberico et al., 2014; Liu et al., 2014	✔	Patel & Burns, 2013
Gestation induced hypertension	✔	Groom et al., 2007	✔	Patel & Burns, 2013
Maternal height	✔	Alberico et al., 2014		
Smoking during pregnancy	✔	Tikellis et al., 2012	✔	Patel & Burns, 2013
Infection and medical conditions during pregnancy	✔	Romero et al., 1988	✔	Patel & Burns, 2013
Maternal social stress	✔	Ruwanpathirana & Fernando, 2014	✔	Carmichael et al., 2007; Andrews & Walker, 1999
Genetic characteristics	✔	Wen et al., 1995	✔	Zhang et al., 2012; Mark et al., 2014
Immigrant status	✔	Verropoulou & Basten, 2014		

Gender is one of the factors that is related to birth weight, as generally females tend to be lighter than males (Alberico et al., 2014; Tikellis et al., 2012). Maternal age, over 35 years of age and teenage mothers, has a relation to lighter birth weight babies (Machado, 2006). It also has been found that a maternal age of less than 25 years of age is related to increased risk of birth defects (Zhang et al., 2012). Findings have been reported that both advanced age (i.e., >40 years-old) and younger maternal age (i.e., <15 years-old) can increase the risk of congenital heart defect (Patel & Burns, 2013). Maternal education level is also associated with infant birth weight (Mahmoodi et al., 2013) and birth defect. There was a relative risk of 1.69 (95% CI=1.58-1.82) times more likely for infants to have a birth defect with mothers who had an education level of less than high school compared to mothers with higher education (Zhang et al., 2012). Household income is another factor related to infant birth weight and birth defects. Household income had an indirect correlation with low birth weight (Mahmoodi et al., 2013) and this study has shown that families with lower household income were at an increased risk of developing Tetralogy of Fallot (Yang et al., 2008). Marital status and multiple births were known to be associated with low birth weight. Marital status has been reported to have an inconsistent correlation with infant low birth weight. There was a report that linked marital status to low birth weight (Verropoulou & Basten, 2014) , while other showed no association (Hinkle et al., 2014). Multiple births infants tend to have lower birth weight than singleton birth infants (Verropoulou & Basten, 2014).

There were controversial discussions about multi-parity, as there were reports that showed results that primiparous women were more likely to have lighter babies, while others reported that non-primiparous women tended to give birth to lighter infants. Most studies concurred with the former hypothesis (Alberico et al., 2014; Park et al., 2011). In addition, parity has been observed as a risk factor for various birth defects. Report from a meta-analysis shown that a total of 11 case-control studies and 3 cohort studies examined the association between high and low parity and congenital heart defect risk, and the estimate of the relative risk of congenital heart defect for the highest versus lowest parity categories was 1.20 (95% CI=1.10-1.31) (Feng et al., 2014). Multiple pregnancies, including threatened abortion (Zhang, Olshan, & Cai, 1994), as well as parity (Feng et al., 2014), are risk factors for birth defects. Women who have been pregnant before are more likely to give birth to infants with birth defects. A study from China reported a higher rate of birth defects in third or later pregnancies (513.0 per 10000), followed by the second pregnancies (194.1 per 10000). Mothers in their first pregnancy had the lowest rate of birth defects with 124.3 per 10000 (Zhang et al., 2012). Pre-pregnancy BMI classified as overweight, obesity and excessive gestational weight gain played a crucial role in delivering extreme high birth weight babies (Li et al., 2013; Ferraro et al., 2012). Overweight pre-pregnancy BMI can also increase the risk of congenital heart defect (Patel & Burns, 2013). Mothers with gestational diabetes mellitus (GDM) are identified to have increased risk of having large for gestational age infants (Alberico et al., 2014). Evidence has indicated that an elevated maternal glucose level in either oral glucose challenge test (GCT), or oral glucose tolerance test (OGTT) was related to an increased risk of giving birth to babies with macrosomia (Liu et al., 2014). Multiple studies have found a positive correlation between hyperglycemia during embryogenesis and the risk of congenital heart defect among infants of diabetic mothers (Patel & Burns, 2013). Gestation induced hypertension in pregnant mothers is recognized as a risk factor for having small for gestational age infants (Groom et al., 2007). Mothers with hypertension during pregnancy were found to have twice the risk of giving birth to an infant with congenital heart defect, but studies has begun to investigate whether it is the underlying hypertension or the medication used for treating hypertension that cause the increased risk (Patel & Burns, 2013). Recently, a study has found that maternal height was also linked to greater risks of macrosomia infants with 9.7% of women taller than 165 cm versus 5.6% among women shorter than 165cm (Alberico et al., 2014).

Smoking during pregnancy is associated with low birth weight and birth defects. Maternal smoking during pregnancy was found to be significantly associated with smaller skinfold measurement in newborns, but this negative association did not account for by placental weight (Tikellis et al., 2012). In addition, smoking during pregnancy was a potential risk for developing congenital heart defect (Patel & Burns, 2013). Infection and medical conditions during pregnancy have been known to cause preterm birth with low birth weight babies (Romero et al., 1988). A history of infertility or the use of assisted reproductive technology including fertility medications, and stressful life style are more likely to result in births of infants with congenital heart defect or other birth defects. Maternal therapeutic drug exposures, such as antidepressant medications, antihypertensive medications, anti-infection medications, folic acid, non-steroidal and anti-inflammatory medication showed inconsistent association with congenital heart defect, as some studies found positive relation but numerous studies reported no correlation. Maternal non-therapeutic drug exposures, such as alcohol, caffeine, cigarette smoking also reported inconsistent results. Parental environmental exposures such as air pollution, chemical exposures, and water contamination demonstrated conflicting association with congenital heart defect (Patel & Burns, 2013).

Maternal stress was found to have a relationship with SGA and birth defect in multiple studies. Higher level of social stress could cause SGA in infants (Ruwanpathirana & Fernando, 2014). The potential mechanism behind social stress and birth defects may be the increased production of corticosteroids that can lead to the birth defect (Carmichael et al., 2007). Increased glucocorticoid level can lead to hyperinsulinemia and insulin resistance, which may be the cause of increased risks of congenital heart defect (Andrews & Walker, 1999). Genetic characteristics such as race and a family history of birth defects also play a part in birth outcomes. Caucasian women usually have heavier babies than Asian women, as Caucasian women in general are taller than Asian women, so it is reasonable that they tend to have heavier infants (Wen et al., 1995). Race is also linked to birth defects. American Indians or Alaska natives had higher prevalence of birth defect than non-Hispanic white; Cubans and Asians had either significantly lower or similar prevalence of birth defect depending on the types of birth defects except for anotia or microtia among Chinese (Mark et al., 2014; Zhang et al., 2012). Families who had a history of birth defects were more likely to have infants with birth defects (RR=11.17; 95% CI=0.95-1.18) (Zhang et al., 2012).

Regarding immigrant status, a study carried out in Hong Kong reported that women from Hong Kong had better outcomes in delivering mean birth weight infants, while women migrant from mainland China and other developed countries had a higher chance of high birth weight babies (Verropoulou & Basten, 2014).

Therefore, maternal demographic factors, physical factors and genetic and environmental factors illustrated a big portion of influence either on both birth weight and birth defects or only on one of them.

2.7. Study Objective

2.7.1. Summary of the Literature Review

Socioeconomic status is a concept usually measured by a person's education, income, residence and insurance status, psychosocial factors and other social support in society. Low socioeconomic status leads to increased risks of adverse pregnancy outcomes (Fujiwara et al., 2013; Kramer et al., 2000). The disadvantage from socioeconomic status will expose mothers to unhealthy behaviors, unsafe chemicals, non- adequate prenatal care and more social stress.

Studies have shown that the place of residence of women has a significant impact on perinatal outcomes, but there is inconsistency in the results. In China, people living in rural districts are usually farmers with lower income as compared to people in urban areas. Furthermore, these areas in China are known for poor hygiene, poor living conditions, insufficient medical workers and hospitals and exposure to multiple chemicals and social pressure. Lack of maternity insurance is another plausible factor impacting perinatal outcomes. Mothers having maternal insurance or not seem to have no direct connection to fetal growth, but mothers without maternity insurance are usually less educated and have lower income, which leads to an indirect impact on infant health. Lower education is associated with poor working conditions and lower income. Poor working conditions include long standing jobs, long working duration, heavy physical work, higher stress, and contact with chemicals. Low income results in poor nutritional support for mothers and fewer doctor visits which influences fetal development (Mahmoodi et al., 2013). In addition, mothers with lower education usually have higher smoking rates than those with higher education(Villar et al., 2013).

2.7.2. Gaps Identified

Many studies have reported on the impact of socioeconomic status on birth outcomes, especially education and income, but most of them are from western countries. Evidence has suggested that low socioeconomic status leads to increased risks of adverse pregnancy outcomes (Kramer et al., 2000). However, the papers previously published only studied the influence of a single factor, of either the health insurance or the residence, on infant birth outcomes (Zhang et al., 2012; Luo st al.,2010; Hanratty, 1996) both showing inconsistent results (Hinkle et al., 2014; Kuehan et al., 2007; Xiao et al., 1990). No study has yet explored the impact of maternal insurance on the Chinese population since maternal insurance is a relatively new initiative.

2.7.3. Research Questions and Hypotheses

In this study, the main focus was to examine the impact of maternal insurance and residence on the selected perinatal outcomes, i.e., unhealthy birth weight and birth defects. My hypothesis was that whether having maternal insurance might influence these perinatal outcomes differently, but it might also depend on the mother's residence status.

Chapter 3: Methods

3.1. Study Design

The data in this thesis were collected from a perinatal cohort study conducted in the Beichen District of the city of Tianjin, China. The study duration was from June 2011 to October 2012, initially to evaluate the impact of blood glucose level at the GDM screening on the perinatal outcome among women migrant works. This data contained maternal information from as early as 12 weeks of pregnancy until labor, and infant information immediately after birth to as late as 3 months after birth. The data collected by people in Tianjin Women and Children Health Centre (TJWCHC) was partially funded by Brock University. The population from Beichen district can represent the general Chinese population and have an almost even number of both rural and urban populations. Several papers have been published using the same dataset (Liu et al., 2014; Leng et al., 2014). Therefore maternal and infant information were used to examine whether maternal insurance and residence have a joint influence on infant's perinatal outcomes.

3.2. Participants

The city of Tianjin is the fourth largest city in China with 14.7 million long-term residents as of the end 2013. The new -born rate in Tianjin is approximately 106,000 each year. Beichen district (Figure 1) is one of the 16 districts in Tianjin, which has a population of 620,000 people with 320,000 long-term residents, 300,000 migrants and nearly 2000 new births every year. Beichen district is located in the northern part of the Tianjin city, which is in the urban fringe with a combination of urban and rural areas. This study was approved by TJWCHC and the Research Ethics Boards from Brock University. The Research Ethic Boards from Brock University also approved this study for secondary use of this dataset. The informed consent forms were provided to all the women in this study and all the participants gave their consents. Data information is stored at the city Women and Children's Health Center (WCHC) with confidentiality. A total number of 2364 pregnant women were registered in this study. The exclusion criteria used in this study were multiple births (i.e., more than one offspring was delivered at the birth), because multiple birth infants are generally lighter than singleton birth infants; mothers' age less than 19 years old due to teenager mothers are likely to have lighter infants; missing information for mother's maternal insurance and residence; missing information for infant weight and gestational week (Appendix I).

Figure 1 Administrative District and Counties in Tianjin

3.3. Perinatal Service Protocol

Pregnant women in Tianjin receive services from a three-level hierarchical prenatal care network: primary hospitals (primary level), the district (WCHC) (secondary level), and the city WCHC (tertiary level). Pregnant women living in Beichen district follow the same procedure required for all pregnant women living in Tianjin. For example, they are required to register in a primary hospital in their district at around the 12'th-gestational week, and undergo a GDM screening test at around 24-28 weeks of gestation age. After 32 weeks, every pregnant woman can be transferred to a preferred hospital where she wants to deliver her infant. Each pregnant woman receives a unique ID after registration connecting her electronically recorded information at each visit to a database located in the city WCHC.

3.4. Data Collection

At registration, a questionnaire was requested of all pregnant woman to provide their basic information including their name, date of birth, height, education, multiple pregnancies, parity, residence status, maternity insurance (yes versus no).

3.5. Measurements

3.5.1. Information Collected at Registration

3.5.1.1. Maternal Insurance and Residence

Pregnant women were asked whether they had maternity insurance in a questionnaire at primary hospital (some of the women's information regarding maternity insurance was collected via a phone call). Women with maternal insurance were coded as 1 and women without maternal insurance were coded as 0. The women without maternal insurance served as the reference in statistical analysis.

Pregnant women's residence as urban or rural areas was based on their registered Huji residence. For example, if the woman was classified as non-agriculture on their registered Huji residence, then she was registered as urban residence. The women living in urban were coded as 1 and living in rural were coded as 2. Rural areas served as reference in statistical analysis, though "rural residence" may not indicate that the pregnant woman is currently living in rural locations.

3.5.1.2. Mother's Other Demographic Information

Pregnant women were asked their date of birth. Maternal age was derived from date of birth. Maternal height was self-reported, but if the mother could not recall her height, then her height would be measured to the nearest 0.1 cm at the time of registration. Pregnant women's education was originally categorized into six groups: less or equal to primary school, middle school, high school or technical secondary school, college, undergraduate university degree, higher than or equal to master degree. In this thesis, the pregnant women's education was grouped in two categories, less or equal to high school or technical secondary school, and more than or equal to college education. Less or equal to high school or technical secondary school was coded as 1 (reference) and more than or equal to college education was coded as 2.

Pregnant women provided primiparity or multiparity information, and miscarriage and abortion were not counted. It was recorded as the original number of giving birth, and was coded as 1 for giving birth to at least one child before, as 0 for being the first time of giving birth (reference). Multiple pregnancies information included giving birth, miscarriage and abortion. Similarly, it was recorded as the original number of pregnancy, and was coded as 1 for having been pregnant before, as 0 for being the first time of pregnancy (reference).

3.5.2. Mother's Information Measurements at GDM Screening

3.5.2.1. Blood Glucose Level

All the pregnant women took a GDM screening test of 1 -hour, 50 -g oral glucose challenge test, at primary hospital at approximately 24-28 gestational weeks. During GCT all the women were given an ingestion of 200 ml of 25% glucose solution, which had to be taken within five minutes. After one hour blood glucose level was measured using a capillary glucose meter with finger blood. Women with a 1-hour GCT result over 7.8mmol/L were informed to take another 75-g OGTT at district level WCHC. The women ingested 300 ml of 25% glucose solution in the morning after overnight fasting of at least 8 hours. Then venous blood glucose levels were measured at fasting, 1-hour and 2-hour respectively in a secondary hospital in order to further diagnose GDM.

3.5.2.2. Other Information Measured at GDM Screening

Pregnant women's BMI was measured during this time, calculated as weight in kilograms divided by height in squared meters. It was used as continuous variable in this study. Pregnant women's blood pressure was measured using a calibrated mercury sphygmomanometer, after a five minutes seated rest period with regular cuff size during GDM screening too. It was used as continuous variable.

3.5.3. Information Collected at Birth or After Birth

3.5.3.1. Birth Weight, Definition of SGA, LGA

Infant birth weight was weighted to the nearest 0.1 g using a digital scale in the delivery suite after the baby was dried but before breast-feeding.

The newborn infants whose weights were between the 10^{th} and 90^{th} percentiles were considered appropriate for gestational age, those below the 10^{th} percentile were small-for-gestational-age (SGA), and those above the 90th percentile were classified as large- for–gestational- age (LGA). The cutoff points for SGA and LGA were based on Tianjin population and gender specific.

3.5.3.2. Other Variables

Gestation week was calculated as weeks + days from the date of last menstrual period to the date of giving birth. Ponderal index was calculated as infant body weight in grams divided by height cube in centimeters timed 100.

3.5.3.3. Infant Information Measurements Regarding Defects

Infant birth defect (except congenital heart defect) was any defect detected right after delivery, before being discharged from hospital. Infants' defects found in this study included congenital heart defect, which constituted over half of the birth defect numbers, and a small number of lip clefts, polydactyly, microtia (including anotia), syndactyly, anal-rectal atresia, talipes equinovarus, and hydranencephaly.

There are many types of birth defects, but congenital heart defect is one of the most common birth defects in the Chinese population (Zhang et al., 2012). Therefore, I focused on this specific type of birth defects and the overall birth defects in this study.

Some newborns had congenital heart defect screening at this time based on their distinct signs for congenital heart defect. Other newborns were required to have congenital heart defect screening in The Women and Children's Health Center (WCHC) of the district in Tianjin after 2-3 months of delivery. Congenital heart defect screenings were performed by recognized doctors from Taida cardiovascular hospital. Color-Doppler Echocardiography was used as a diagnostic tool for the diagnosis of congenital heart defect. Echocardiograph screenings of congenital heart defect were made according to the echocardiograph procedure of congenital heart defect.

Congenital heart defect was defined as structural abnormality of the heart or great vessels identified through echocardiography. Children were defined as having a congenital heart defect if they were diagnosed as congenital heart defect by two cardiologists. Children diagnosed as congenital heart defect would undergo cardiac catheterization before undergoing cardiac surgery. The predominant defect was the diagnosis in cases where various congenital heart defects existed at the same time. Atrial septal defect (ASD) was defined as having a defect and shunt at the interatrial septal level between the left and right atria, but which does not include the patent foramen oval. Ventricular septal defect (VSD) was defined as having a defect at the interventricular septal level between the left and right ventricles. Patent ductus arteriosus (PDA) was defined as having a continuous patency of the vessel, which linked the left pulmonary artery to the descending thoracic aorta after birth. Pulmonary stenosis was defined as having a difficulty (increased velocity>2.0m/s) to pump blood flow from heart's right ventricle to the pulmonary artery. Single ventricle was defined as having only one ventricular chamber instead of two atrioventricular valves or a large ventricle related with a mini-opposing ventricle. Ebstein's anomaly was defined as displacement of the septal and posterior tricuspid valve leaflets from the annulus into the right ventricular cavity.

3.5.4. Other Factors that Are Not Big Concerns

3.5.4.1. Marital Status

Dataset contained fathers' occupation, age, and education. However, such information could not indicate pregnant women's marital status as married. Previous study exploring the effect of national health insurance on infant health pointed out that implementation of national health insurance has a larger influence on single mothers than married mothers. Married mothers showed no difference before or after the implementation of national health insurance on infant low birth weight; while for single mothers it reduced infant low birth weight by 8.9% (Hanratty, 1996). This makes sense as single mothers are in most need for medical and financial help and they have the least access to health care prior to the introduction of national health insurance. However, according to a survey from 20539 Tianjin pregnant women conducted by the same colleagues who collected this study dataset, more than 99% of the pregnant women were married. Therefore, the single mother influence among Chinese pregnant women is fairly small.

3.5.4.2. Pre-Pregnancy BMI

The dataset has BMI measurement during GDM screening instead of pre-pregnancy BMI. Maternal BMI varies among pregnant women with different gestational age, but confining the participant gestational age within 24-28 weeks of gestation and adjusting gestational age can reduce the bias. So I decided to BMI measured at 24-28 weeks of gestation as a continuous variable in this study.

3.5.5. Validity of the Measurements

There may be inaccuracy in the recording of pregnant women's height, or gestational age, which may have an impact on the calculation of SGA and LGA. At pregnancy most women's height was self-reported, which may introduce recall bias into the study. Studies investigating the validity of self-reported height and weight concluded that the estimated self-reported height and weight were actually accurate (Niedźwiedzka, Długosz, & Wądołowska, 2015). The calculation of gestational age was based on the date of last menstrual period of self report. Similarly, gestational age estimated from self-reported last menstrual period did not differ significantly from gestational age assessed by ultrasound method (Olesen et al., 2004). In conclusion, self-reported measurements are largely valid and are recommended for research use, and the bias introduced is limited that can be ignored.

3.6. Statistical Analysis

3.6.1. Methods Used In the Study

All the statistical analysis was conducted using SAS 9.4 with two-tailed test. The type 1 error (α) was set at a 0.05 level for statistical significance. Student t-tests were used for continuous variables and $\mathcal{X}^2$ tests were used for category variables between groups. ANOVA was used for continuous variables with more than two groups. Odds ratios (ORs) and 95% confidence intervals (95% CI) from multivariable logistic regressions were used to examine the impact of maternal insurance and/or maternal residence on SGA, LGA, birth defect (including congenital heart defect), or congenital heart defect alone.

3.6.2. Analysis of Association between Maternal Insurance and/or Residence and Unhealthy Birth Weight

To analyze the association between maternal insurance, residence and SGA or LGA, residence was first analyzed independently. Residence was the independent variable and SGA or LGA infant was the dependent variable. When exploring joint effect of maternal insurance and residence, maternal insurance was put into models stratified by residence status (urban versus rural). Maternal insurance was the independent variable and SGA or LGA was the dependent variable. For each of the two selected perinatal outcomes, three models were generally used to examine the impact of joint effect of maternal insurance and residence on infants' birth weight. Model one was adjusted for mother's demographic conditions: age, height, education; model two was further adjusted for maternal physical conditions, measured at oral GCT screening: maternal BMI, systolic blood pressure, blood glucose level; model three was further adjusted for mother's past historical information as to multiple pregnancies, and parity. So in total, there were 9 models in the analysis for SGA or LGA separately (Figure 2).

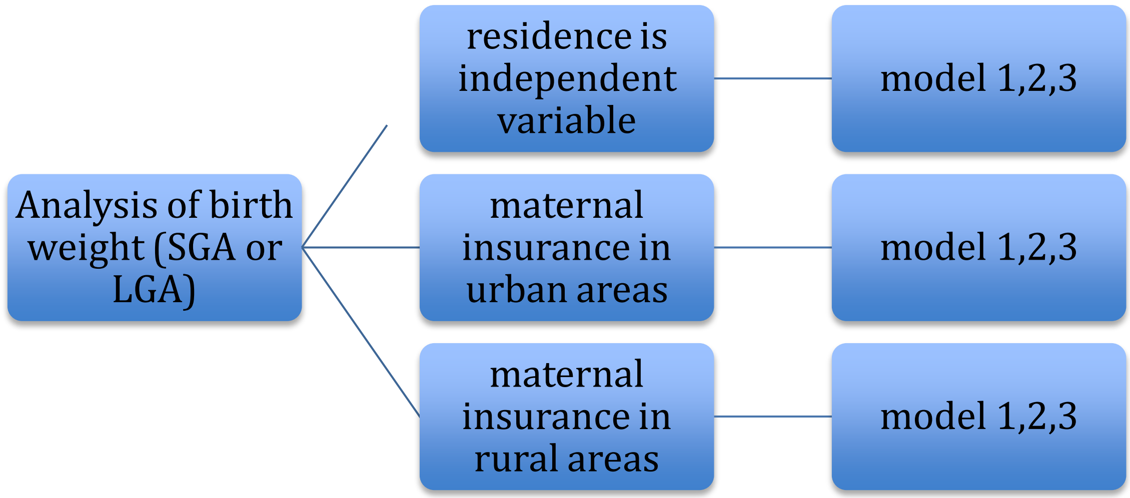

Figure 2 Statistical Analysis of Association between Maternal Insurance and/or Residence and Unhealthy Birth Weight

3.6.3. Analysis of Association of Maternal Insurance and/or Residence and Infant Defect

Similarly, when analyzing the relationship between maternal insurance, residence and birth defect (including congenital heart defect) or congenital heart defect alone, firstly introduce residence into the models as independent predictor. Then maternal insurance was put into models stratified by residence status (urban versus rural) to analyze joint effect of maternal insurance and residence. Each relationship analysis had five models accumulatively adjusting for different covariates. Model one was adjusted for infant information as sex; model two was further adjusted for mother's demographic condition: age, and education; model three was further adjusted for maternal physical conditions: maternal BMI, systolic blood pressure, height, and blood glucose level measured at oral GCT screening; model four was further adjusted for mother's past historical condition and infant's conditions: parity, SGA and LGA; model five was further adjusted for multiple pregnancies. I decided to put multiple pregnancies in the last model due to multiple pregnancies had a greater effect on birth defect, and putting it in the model four may cover the effect of parity, SGA or LGA. Due to small sample size of rural insured mothers who gave birth to infants with birth defect or congenital heart defect, in the analysis of the relationship between maternal insurance and birth defect or congenital heart defect in rural regions, only first model was applied. There were 11 different models in the analysis for infant defect (including congenital heart defect) or congenital heart defect alone separately (Figure 3).

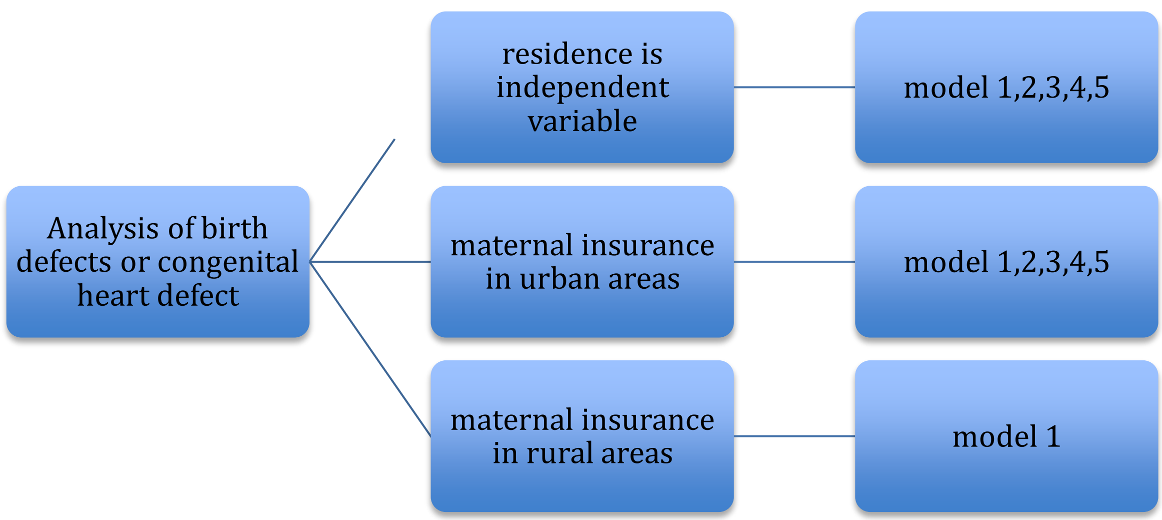

Figure 3. Statistical Analysis of Association of Maternal Insurance and/or Residence and Infant Defect

3.6.4. Internal Validation

In order to internally validate the results generated from the models in this study, bootstrapping techniques were applied because it was statistically inefficient to set aside data separately developed. Bootstrapping is used to assess the stability of p- value and confidence interval as a measure of accuracy of the statistical estimates without knowing the type of distribution from which the samples have been taken (Barker, 2005). Bootstrapping is especially useful when the assumptions about normal distribution, linearity and analysis of variance of conventional methods are violated. When using bootstrapping, data set is considered as a random sample. Empirical research suggested that repeated random bootstrapping samples containing the same observation size as the original sample with replacement obtained the best results (Barker, 2005). These bootstrapping samples then were used to estimate a given model to measure the accuracy of the estimates. In this study, 1000 repeated bootstrapping samples with replacement as the same size as the original sample were obtained to re-estimate model parameters. 95% confidence intervals of odds ratio of all the variables from logistic regression and ROC(C) value for final model evaluation in independent and joint analysis were recorded from each new bootstrapping sample. Probability proportional to size and with replacement selection method was applied to generate 1000 random samples using blood glucose level measured at oral blood glucose challenge test as the proportional size variable. Blood glucose levels were categorized as low (<6.0mmol/L), normal (6.0mmol/L, 7.8mmol/L), and high (>7.8mmol/L) for proportional sample selection.

Chapter 4 Results

The results in this chapter are presented in three parts. First, demographic characteristics of the study sample are presented by infant sex or maternal insurance status separated by residence. Second, the association between maternal insurance and either small for gestational age (SGA), or larger for gestational age (LGA) infants using logistic regression models is shown by residence separately. Finally, the association between maternal insurance and either infant overall birth defects or congenital heart defect, separated by residence status using logistic regression is shown in tables and figures.

4.1. Demographic Characteristics

4.1.1. Basic Characteristics of the Study Sample by Infant Sex

The characteristics of the study sample by infant sex are presented in Table 5. Of the 2309 singletons at birth, 1171 (50.7%) were males, and 1138 (49.3%) were females. There were 217 (9.4%) infants categorized as SGA and 248 (10.7%) infants categorized as LGA based on Tianjin criteria. 48 (2.1%) infants were found to be born with birth defects, which included 32 (66.7%) congenital heart defects.

Mothers' age, education, and urban residence status were similar between sexes of infants. However, compared to female infants, male infants were more likely to be conceived by mothers who had maternal insurance (54.2% versus 48.8%, p<0.01).

Maternal height, BMI, and blood glucose levels measured at oral glucose challenge test were similar for both sexes of infants; however mothers of male infants had a higher average of systolic blood pressure compared to mothers of female infants (109.3 versus 107.9mmHg, $p<0.01$).

The status of being first time of pregnancy was similar for mothers between sexes of infants. However, compared to mothers of female infants, mothers of male infants were more likely to be primiparous (85.1% versus 81.4%, $p<0.05$).

The Infants had similar characteristics between sexes for Ponderal index (2.7 versus 2.7g/cm^3, NS), presence of birth defect (2.1% versus 2.0%, NS), or born with congenital heart defect (1.2% versus 1.6%, NS), SGA (9.5% versus 9.3%, NS) and LGA (10.3% versus 11.3%, NS). Male infants however, on average were 81.9 g heavier than female infants (3423.8 versus 3341.9g, $p<0.0001$) even though they had on average 0.2 weeks shorter gestational age (39.4 versus 39.6 weeks, $p<0.01$).

Table 5 Selected characteristics by infant's sex

Variable	Boys N=1171	Girls N=1138	P-Value
Mother's demographic information			
Age (years, mean (SD))	26.9(3.6)	27.1(3.9)	NS
Education ≤high school (% (N))	41.3(470)	45.3(497)	NS
Have maternal insurance (%(N))	54.2(635)	48.8(555)	<0.01
Urban residence (% (N))	75.3(882)	70.1(798)	<0.01
Mother's physical conditions measured at oral glucose challenge test			
Height (cm, mean (SD))	162.6(4.9)	162.4(4.7)	NS
BMI (kg/m^2, mean (SD))	25.6(3.5)	25.6(3.8)	NS
Systolic blood pressure (mmHg, mean (SD))	109.3(11.3)	107.9(10.9)	<0.01
Blood glucose level (mmol/L, mean (SD))	7.1(1.5)	7.1(1.6)	NS
Mother's past historical conditions			
First time of pregnancy (% (N))	59.9(701)	58.9(670)	NS
Parity (primiparity) (% (N))	85.1(997)	81.4(926)	<0.05
Infant's conditions			
Weight (g, mean (SD))	3423.8(441.6)	3341.9(462.6)	<.0001
Gestational age (week, mean (SD))	39.4(1.3)	39.6(1.4)	<0.01
Ponderal index (g/cm^3, means (SD))	2.7(0.3)	2.7(0.3)	NS
Infant has defect (% (N))	2.1(25)	2.0(23)	NS
Infant born with congenital heart defect (% (N))	1.2(14)	1.6(18)	NS
SGA	9.5(111)	9.3(106)	NS
LGA	10.3(120)	11.3(128)	NS

Abbreviation: SGA, small for gestational age; LGA, large for gestational age; BMI, body mass index

Note: Infant has defect includes congenital heart defect

4.1.2. Characteristics by Maternal Insurance Status and Residence Status.

72.8% (1680) of mothers lived in urban areas, and 27.2% (629) lived in rural areas. Of the women who lived in urban areas, 68.3% (1148) had maternal insurance; while among women who lived in rural areas, only 6.7% (42) had maternal insurance (Table 6, Figure 4). Due to a significant difference in the ownership of maternal insurance between urban and rural areas, it may not be appropriate to combine both residence statuses together to examine the impact of maternal insurance on the selected birth outcomes. Therefore, the demographic information was presented by maternal insurance status according their residence status.

Table 6 Birth outcomes by insurance and residence status

(N)	Urban (1680)		Rural (629)	
	Insured	Not insured	Insured	Not insured
N (%)	1148 (68.3)	532 (31.7)	42 (6.7)	587 (93.3)
SGA (N [%])	112 (9.8)	45 (8.5)	2 (4.8)	58 (9.9)
LGA (N [%])	113 (9.8)	64 (12.0)	9 (21.4)	62 (10.6)
Birth defect (N [%])	17 (1.5)	10 (1.9)	3 (7.1)	18 (3.1)
Congenital heart defect (N [%])	11 (1.0)	6 (1.2)	2 (4.8)	13 (2.3)

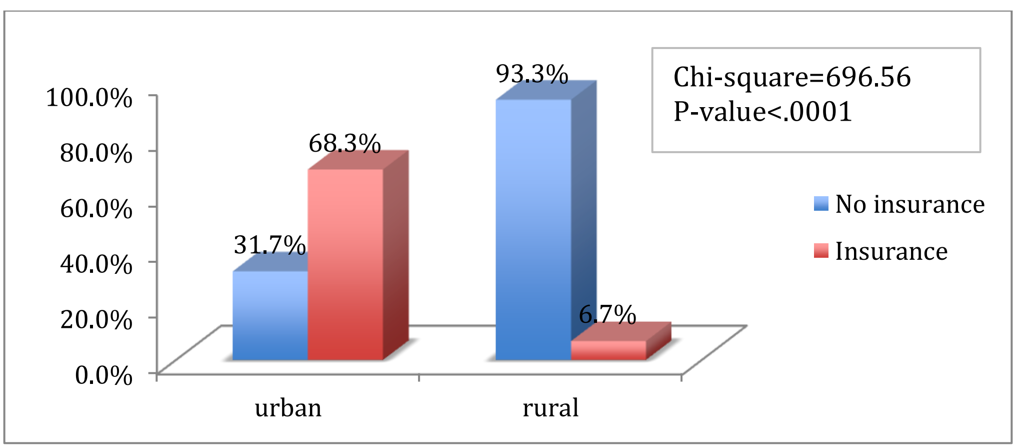

Figure 4 Percentage of Women Possessed Maternal Insurance by Residence Status

4.1.2.1. Selected Characteristics of Mothers Living in Urban Areas

The selected characteristics by insurance status in urban areas are presented in Table 7. Mothers who had maternal insurance tended to be older (27.5 versus 26.7 years, $p<0.0001$) and more educated – education higher than high school (83.0% versus 45.5%, $p<0.0001$) than mothers without maternal insurance.

The mothers' physical conditions measured at the oral glucose challenge test such as blood glucose levels and body mass index were not significantly different. Mothers' heights were found to be similar regardless of mothers' insurance status. However, mothers' systolic blood pressure was on average 1.2 mmHg higher for mothers without maternal insurance (108.7 versus 107.5mmHg, $p<0.05$).

Mothers' historical conditions did show quantity differences. Mothers who were pregnant for the first time as well as giving birth to a child for the first time were significantly more likely to have maternal insurance (69.8% versus 51.9%, $p<0.0001$ and 95.5% versus 82.3%, $p<0.0001$ respectively).

In the analysis of infant characteristics, infants' sex as male, birth weight, gestational age, Ponderal index, born with birth defect or congenital heart defect, SGA and LGA were not significantly different by insurance status.

Table 7 Selected characteristics by insurance status in urban areas

Variable	No insurance N=532	Insurance N=1148	P-value
Mother's demographic information			
Age (years, mean (SD))	26.7(3.6)	27.5(3.0)	<.0001
Education ≤high school (% (N))	55.5(289)	17.0(190)	<.0001
Mother's physical conditions measured at oral glucose challenge test			
Height (cm, mean (SD))	162.8(4.8)	162.4(4.8)	NS
BMI (kg/m^2, mean (SD))	25.5(3.7)	25.3(3.3)	NS
Systolic blood pressure (mmHg, mean (SD))	108.7(10.9)	107.5(11.1)	<0.05
Blood glucose level (mmol/L, mean (SD))	7.1(1.6)	7.1(1.5)	NS
Mother's past historical conditions			
First time of pregnancy (% (N))	51.9(276)	69.8(801)	<.0001
Parity (primiparity) (% (N))	82.3(438)	95.5(1096)	<.0001
Infant's conditions			
Sex as male	49.8(265)	53.8(617)	NS
Weight (g, mean (SD))	3414.0(447.9)	3375.4(447.8)	NS
Gestational age (week, mean (SD))	39.5(1.3)	39.5(1.4)	NS
Ponderal index (g/cm^3, means (SD))	2.7(0.3)	2.7(0.3)	NS
Infant has defect (% (N))	1.9(10)	1.5(17)	NS
Infant born with congenital heart defect (% (N))	1.2(6)	1.0(11)	NS
SGA	8.5(45)	9.8(112)	NS
LGA	12.0(64)	9.8(113)	NS

Abbreviation: SGA, small for gestational age; LGA, large for gestational age; BMI, body mass index

Note: Infant has defect includes congenital heart defect

4.1.2.2. Selected Characteristics of Mothers Living in Rural Areas

The selected characteristics by insurance status in rural areas are presented in Table 8. Similar to mothers in urban areas with maternal insurance, mothers in rural areas with maternal insurance were older than mothers without maternal insurance (28.0 versus 26.3 years, $p<0.05$). No significant differences were found between mothers with or without insurance in terms of education, height, or physical conditions measured at oral glucose challenge test.

Unlike mothers with maternal insurance in urban areas, it was found that mothers with maternal insurance in rural areas were more likely to have delivered a child before (47.6% versus 62.9%, $p<0.05$) compared to mothers without maternal insurance.

Compared to infants born to mothers without maternal insurance, infants born to mothers with maternal insurance were on average 170.9g heavier (3531.7 versus 3360.8g, $p<0.05$). Other characteristics, such as sex as male, gestational age, Ponderal index, born with birth defect or congenital heart defect, SGA and LGA were not significantly different.

Table 8 Selected characteristics by insurance status in rural areas

Variable	No insurance N=552	Insurance N=42	P-value
Mother's demographic information			
Age (years, mean (SD))	26.3(4.9)	28.0(5.2)	<0.05
Education ≤high school (% (N))	82.3(454)	81.0(34)	NS
Mother's physical conditions measured at oral glucose challenge test			
Height (cm, mean (SD))	162.2(4.8)	163.2(5.3)	NS
BMI (kg/m^2, mean (SD))	26.1(4.1)	26.2(3.5)	NS
Systolic blood pressure (mmHg, mean (SD))	110.6(11.2)	109.4(9.1)	NS
Blood glucose level (mmol/L, mean (SD))	6.9(1.6)	7.3(1.6)	NS
Mother's past historical conditions			
First time of pregnancy (% (N))	47.0(276)	42.9(18)	NS
Parity (primiparity) (% (N))	62.9(369)	47.6(20)	<0.05
Infant's conditions			
Sex as male	46.2(271)	42.9(18)	NS
Weight (g, mean (SD))	3360.8(467.7)	3531.7(463.5)	<0.05
Gestational age (week, mean (SD))	39.4(1.4)	39.6(1.3)	NS
Ponderal index (g/cm^3, means (SD))	2.7(0.4)	2.8(0.3)	NS
Infant has defect (% (N))	3.1(18)	7.1(3)	NS
Infant born with congenital heart defect (% (N))	2.3(13)	4.8(2)	NS
SGA	9.9(58)	4.8(2)	NS
LGA	10.6(62)	21.4(9)	<0.05

Abbreviation: SGA, small for gestational age; LGA, large for gestational age; BMI, body mass index

Note: Infant has defect includes congenital heart defect

4.2. Health Impact of Insurance for Urban Residence

4.2.1. SGA

There were a total of 217 (9.4%) SGA; 157 (72.4%) were born to mothers with urban residence and 60 (27.6%) were born to mothers with rural residence. The total number of insured mothers in urban areas was 1148 (68.3%) and the total number uninsured in urban areas was 532 (31.7%). Of this urban group, 112 (9.8%) SGA infants were born to mothers with maternal insurance and 45 (8.5%) were born to mothers without maternal insurance (Figure 5).

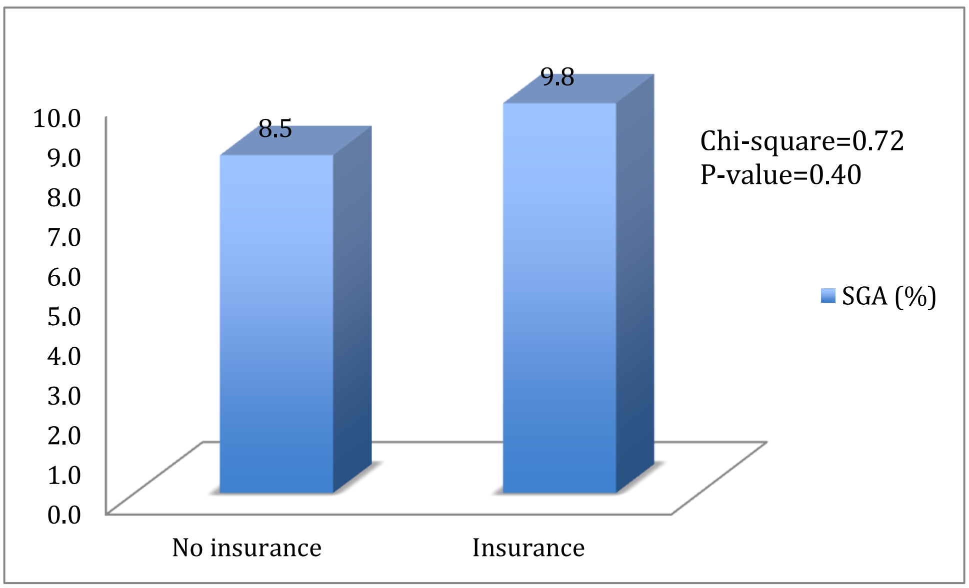

Figure 5 Pencentage of SGA by Insurance Status in Urban Areas

Adjusted odds ratios of SGA by maternal insurance in urban areas are presented in Table 9. The odds ratios of having a SGA infant for mothers with insurance was approximately 1.2 (1.19, 95% CI (0.80, 1.78), NS) compared to mothers without insurance, after adjusting for maternal age, height and education (model 1, C value=0.613). The further adjustment of blood glucose level, BMI, and systolic blood pressure measured at blood glucose challenge test, (model 2, C value=0.646) and of multiple pregnancies and parity (model 3, C value=0.645) did show an increase in odds ratio, but none of them reached statistical significance. Among covariates in the final model, only maternal height and BMI affected the odds ratio of delivery of a SGA infant. Increase in height decreased the odds of having a SGA infant by 5% (0.95, 95% CI (0.91, 0.98), $p<0.01$). Increase in BMI decreased the odds of having a SGA infant by 11% (0.89, 95% CI (0.84, 0.95), $p<0.001$)

Table 9 Adjusted odds ratio of SGA for maternal insurance in urban areas

	Model 1			Model 2			Model 3		
Variable	ORs	95% CI	P-value	ORs	95% CI	P-value	ORs	95% CI	P-value
Maternal insurance	1.19	(0.80,1.78)	NS	1.35	(0.88,2.08)	NS	1.32	(0.85,2.04)	NS
Age	**0.91***	(0.86,0.96)	<0.01	0.95	(0.89,1.01)	NS	0.95	(0.89,1.02)	NS
Height	**0.95***	(0.91,0.98)	<0.01	**0.95***	(0.91,0.98)	<0.01	**0.95***	(0.91,0.98)	<0.01
Education ≥high school	1.03	(0.69,1.55)	NS	0.95	(0.62,1.47)	NS	0.92	(0.59,1.44)	NS
Blood glucose level				0.89	(0.78,1.01)	NS	0.89	(0.78,1.01)	NS
BMI				**0.89***	(0.84,0.95)	<0.001	**0.89***	(0.84,0.95)	<0.001
Systolic blood pressure				1.01	(0.99,1.03)	NS	1.02	(0.99,1.03)	NS
Multiple pregnancies							1.05	(0.70,1.58)	NS
Parity (Gave birth to a child before)							0.70	(0.27,1.79)	NS
C value		0.613			0.646			0.645	

Note: Mother has no maternal insurance is the reference, mother was primiparous is the reference for parity and multiple pregnancies

* means result reaches statistical significance

4.2.2. LGA

There were a total of 247 (10.7%) LGA infants, with 71% (177) born to mothers living in urban areas. In the urban areas, 64 (12.0%) LGA infants were born to mothers without maternal insurance, and 113 (9.8%) were born to mothers with maternal insurance (Figure 6).

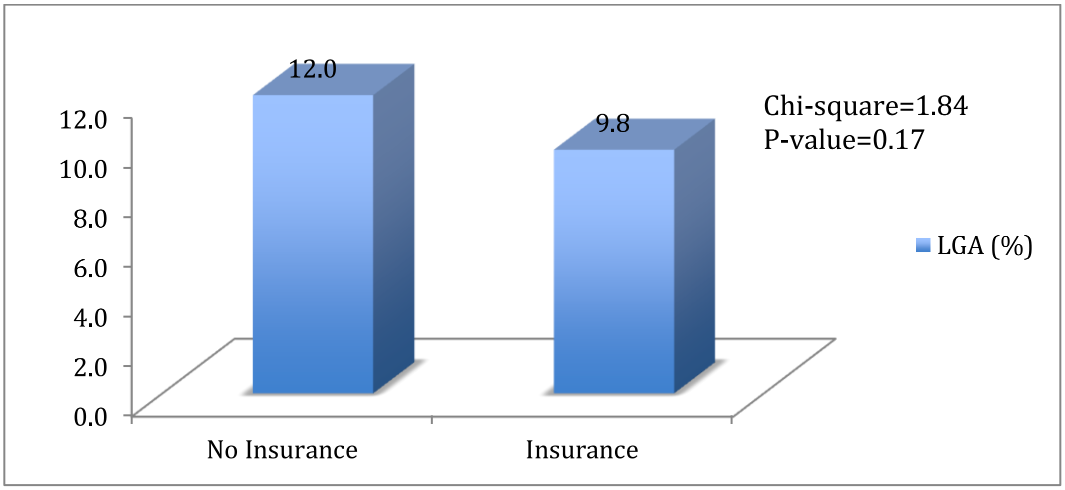

Figure 6 Percentage of LGA by Insurance Status in Urban Areas

Adjusted odds ratios of delivery of LGA infants for mothers with maternal insurance in urban areas are presented in Table 10. Having maternal insurance decreased the odds of delivering LGA infants by 16% (0.84, 95% CI (0.59, 1.21), NS) in urban areas in model 1 (C value=0.597), adjusting the same covariates as in the SGA analysis, though it did not reach statistical significance. When further adjusting for more covariates in model 2 (C value=0.679), the odds ratio did not change significantly. In model 3 (C value=0.690), further adjusting all the covariates, having maternal insurance decreased the odds of having LGA infants by 8% (0.92, 95% CI (0.62, 1.36), NS). Among covariates in model3, higher maternal height and BMI increased the odds of delivering a

LGA infant by 7% (1.07, 95% CI (1.03, 1.11), $p<0.001$), and 14% (1.14, 95% CI (1.09, 1.20), $p<0.0001$) respectively. Additionally, mothers who had multiple pregnancies had 53% (1.53, 95% CI (1.04, 2.23), $p<0.05$) higher odds of giving birth to LGA infants.

Table 10 Adjusted odds ratio of LGA for maternal insurance in urban areas

	Model 1			Model 2			Model 3		
Variable	ORs	95% CI	P-value	ORs	95% CI	P-value	ORs	95% CI	P-value
Maternal insurance	0.84	(0.59,1.21)	NS	0.85	(0.58,1.25)	NS	0.92	(0.62,1.36)	NS
Age	**1.08***	(1.03,1.13)	<0.01	**1.06***	(1.01,1.11)	<0.05	1.04	(0.98,1.10)	NS
Height	**1.06***	(1.03,1.10)	<0.001	**1.07***	(1.03,1.11)	<0.001	**1.07***	(1.03,1.11)	<0.001
Education ≥high school	0.85	(0.59,1.23)	NS	0.93	(0.63,1.38)	NS	1.05	(0.70,1.59)	NS
Blood glucose level				1.05	(0.94,1.17)	NS	1.05	(0.94,1.17)	NS
BMI				**1.15***	(1.09,1.20)	<.0001	**1.14***	(1.09,1.20)	<.0001
Systolic blood pressure				1.00	(0.98,1.02)	NS	1.00	(0.98,1.02)	NS
Multiple pregnancies							**1.53***	(1.04,2.23)	<0.05
Parity (Gave birth to a child before)							1.23	(0.67,2.26)	NS
C value		0.597			0.679			0.690	

Note: Mother has no maternal insurance is the reference, mother was primiparous is the reference for parity and multiple pregnancies

* means result reaches statistical significance

4.2.3. Birth Defects

There were 48 (2.1%) infants born with birth defect (including congenital heart defect), and 56% (27) of them were born in urban areas. Among all the infants with birth defect in urban areas, 10 (1.9%) were born to mothers without maternal insurance, 17 (1.5%) born to mothers with maternal insurance (Figure 7).

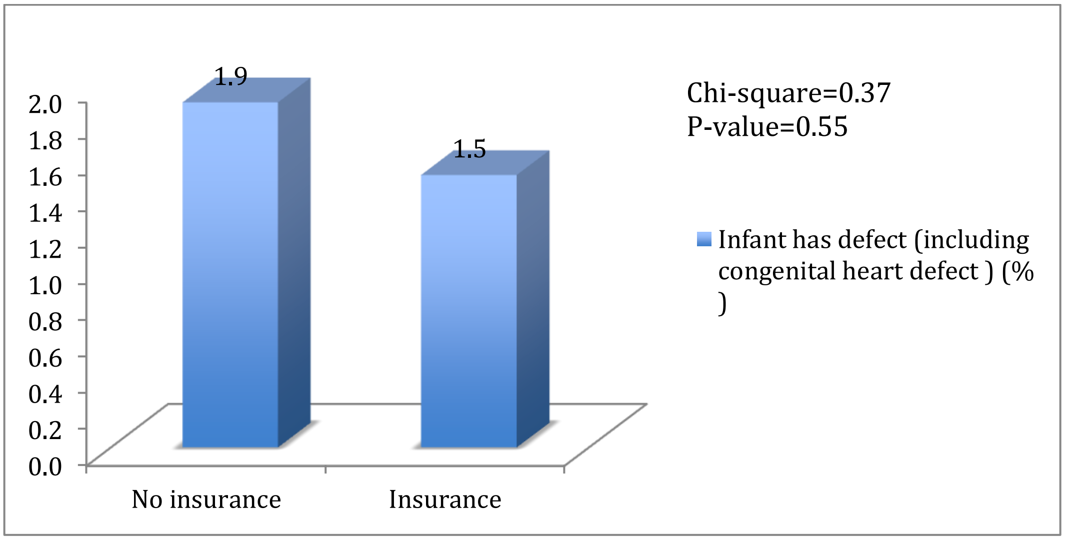

Figure 7 Percentage of Infants Born with Birth Defect (Including Congenital Heart Defect) by Insurance Status in Urban Areas

The adjusted odds ratios of infants born with birth defect in urban areas are presented in Table 11. Odds ratio illustrated that possession of maternal insurance decreased the odds of infants born with birth defect in urban areas by approximately 21% (0.79, 95% CI (0.36, 1.74), NS) after adjusting infants' sex (model1, C value=0.543), but it was not statistically significant. The strength of the odds ratio decreased a little to 19% (0.81, 95% CI (0.34, 1.91), NS) after further adjusting for maternal age and education (model 2,C value=0.572). When further adjusting for additional covariates, such as maternal height, blood glucose level, BMI, systolic blood pressure (model 3, C value=0.609), parity, SGA, LGA (model 4, C value=0.612), and multiple pregnancies (model 5, C value=0.675), the relationship between having maternal insurance and birth defect did not change with odds ratio of 0.93 (95% CI (0.37, 2.33), NS) in the final model. In the final model, mothers with multiple pregnancies had 2.85 (95% CI (1.20, 6.78), $p<0.05$) higher times of odds of having an infant born with birth defect in final model.

Table 11 Adjusted odds ratio of infant birth defect (including congenital heart defect) for maternal insurance in urban areas

	Model 1			Model 2			Model 3			Model 4			Model 5		
Variable	ORs	95% CI	P	ORs	95% CI	P	ORs	95% CI	P	ORs	95% CI	P	ORs	95% CI	P
Maternal Insurance	0.79	(0.36,1.74)	NS	0.81	(0.34,1.91)	NS	0.82	(0.33,2.02)	NS	0.85	(0.34,2.12)	NS	0.93	(0.37,2.33)	NS
Infant's sex as male	0.85	(0.39,1.81)	NS	0.85	(0.40,1.82)	NS	0.98	(0.44,2.18)	NS	0.99	(0.44,2.19)	NS	0.94	(0.42,2.09)	NS
Age				1.05	(0.94,1.17)	NS	1.04	(0.92,1.17)	NS	1.03	(0.90,1.17)	NS	1.00	(0.88,1.15)	NS
Education ≥high school				0.89	(0.37,2.15)	NS	0.94	(0.37,2.38)	NS	0.99	(0.38,2.61)	NS	1.11	(0.42,2.92)	NS
Height							0.98	(0.90,1.07)	NS	0.98	(0.90,1.07)	NS	0.98	(0.90,1.07)	NS
Blood glucose level							1.09	(0.85,1.40)	NS	1.09	(0.84,1.40)	NS	1.08	(0.84,1.40)	NS
BMI							0.95	(0.83,1.08)	NS	0.95	(0.83,1.08)	NS	0.94	(0.83,1.08)	NS
Systolic blood pressure							1.02	(0.98,1.06)	NS	1.02	(0.98,1.06)	NS	1.02	(0.98,1.06)	NS
Parity (gave birth to a child before)										1.34	(0.32,5.51)	NS	0.86	(0.21,3.55)	NS
SGA infant VS Normal infant										0.86	(0.20,3.76)	NS	0.84	(0.19,3.71)	NS
LGA infant VS Normal infant										1.15	(0.33,4.02)	NS	1.07	(0.31,3.76)	NS
Multiple pregnancies													**2.85***	(1.20,6.78)	<0.05
C value		0.543			0.572			0.609			0.612			0.675	

Note: Mother has no maternal insurance is the reference, mother was primiparous is the reference for parity and multiple pregnancies

* means result reaches statistical significance

4.2.4. Congenital Heart Defect

There were a total of 32 (1.4%) infants born with congenital heart defect, and 53% (17) of them were in urban areas. In the urban areas, 6 (1.2%) were born to mothers without maternal insurance, and 11 (1.0%) born to mothers with maternal insurance (Figure 8).

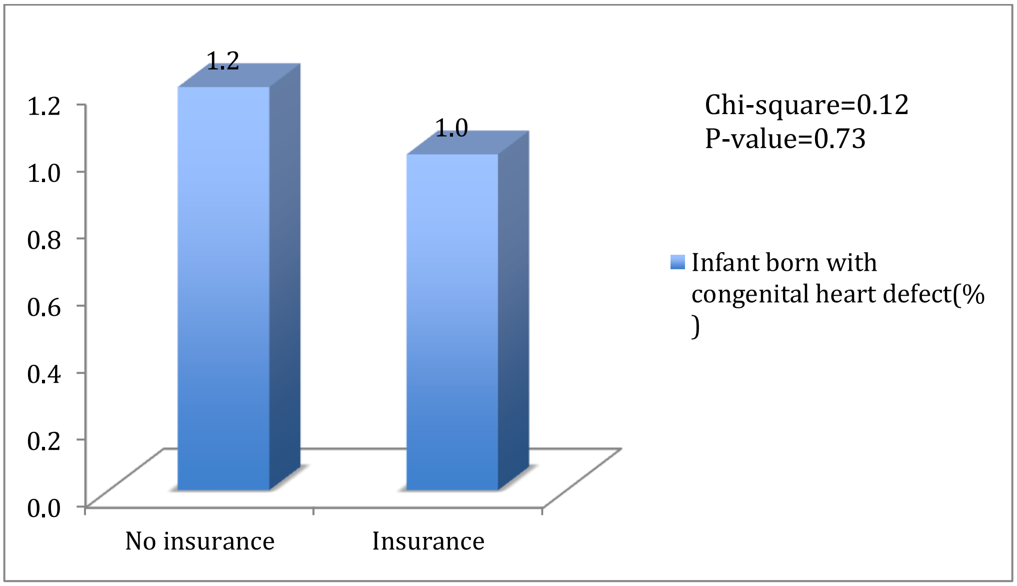

Figure 8 Percentage of Infants Born with Congenital Heart Defect by Insurance Status in Urban Areas

In urban areas, having maternal insurance decreased the odds of infants born with congenital heart defect by roughly 45% (0.65, 95% CI (0.21, 1.99), NS) in final model (C value=0.730), after adjusting for all the covariates: infant sex, maternal age, education, height, blood glucose level, BMI, systolic blood pressure, parity, SGA, LGA, and multiple pregnancies. No statistical significances of the variable maternal insurance were presented in all five models, as well as covariates (Table 12).

Table 12 Adjusted odds ratio of infant congenital heart defect for maternal insurance in urban areas

	Model 1			Model 2			Model 3			Model 4			Model 5		
Variable	ORs	95% CI	P	ORs	95% CI	P	ORs	95% CI	P	ORs	95% CI	P	ORs	95% CI	P
Maternal Insurance	0.86	(0.32,2.35)	NS	0.61	(0.21,1.80)	NS	0.57	(0.19,1.69)	NS	0.60	(0.19,1.82)	NS	0.65	(0.21,1.99)	NS
Infant's sex as male	0.49	(0.18,1.33)	NS	0.48	(0.18,1.32)	NS	0.53	(0.19,1.47)	NS	0.51	(0.18,1.42)	NS	0.49	(0.17,1.37)	NS
Age				1.09	(0.94,1.26)	NS	1.09	(0.93,1.27)	NS	1.08	(0.91,1.27)	NS	1.06	(0.90,1.25)	NS
Education ≥high school				2.36	(0.62,9.04)	NS	2.32	(0.59,9.09)	NS	2.64	(0.63,11.10)	NS	2.86	(0.69,11.81)	NS
Height							1.01	(0.91,1.12)	NS	1.01	(0.91,1.13)	NS	1.02	(0.91,1.13)	NS
Blood glucose level							1.13	(0.83,1.53)	NS	1.14	(0.84,1.55)	NS	1.15	(0.83,1.57)	NS
BMI							0.96	(0.82,1.13)	NS	0.98	(0.83,1.15)	NS	0.97	(0.82,1.15)	NS
Systolic blood pressure							1.01	(0.97,1.06)	NS	1.01	(0.97,1.06)	NS	1.01	(0.96,1.06)	NS
Parity (gave birth to a child before)										1.91	(0.33,10.99)	NS	1.26	(0.22,7.29)	NS
SGA infant VS Normal infant										1.58	(0.34,7.30)	NS	1.54	(0.33,7.16)	NS
LGA infant VS Normal infant										0.50	(0.06,3.99)	NS	0.48	(0.06,3.80)	NS
Multiple pregnancies													2.47	(0.84,7.28)	NS
C value		0.565			0.654			0.665			0.688			0.730	

Note: Mother has no maternal insurance is the reference, mother was primiparous is the reference for parity and multiple pregnancies

* means result reaches statistical significance

4.3. Health Impact of Insurance for Rural Residence

4.3.1. SGA

A total of 60 SGA infants (28%, out of all the SGA infants) were identified in rural areas. 58 (9.9%) were born to mothers without maternal insurance, 2 (4.8%) born to mothers with maternal insurance (Figure 9). Fisher exact test was applied to calculate the p-value.

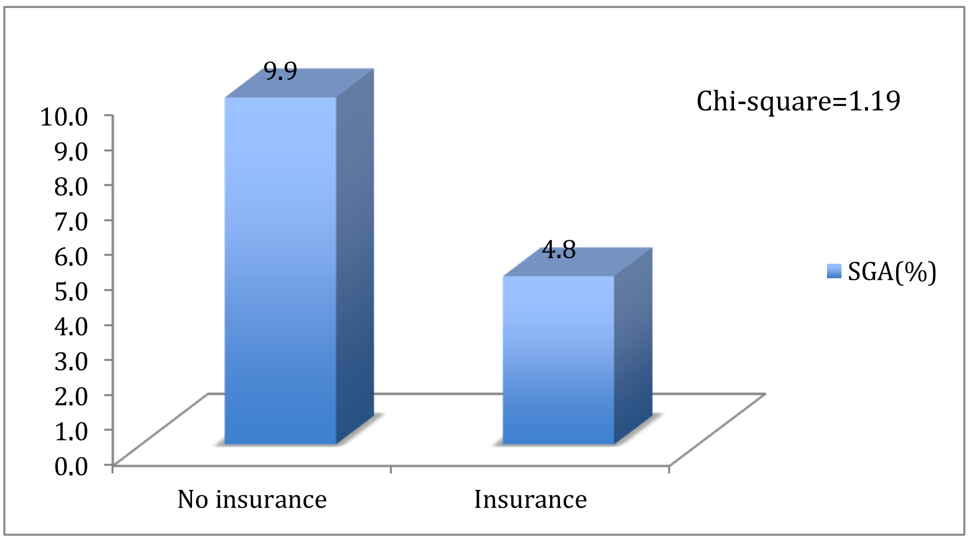

Figure 9 Percentage of SGA by Insurance Status in Rural Areas

Unlike women in urban areas, it was found that in rural areas, having maternal insurance had a 40% (0.60, 95% CI (0.13, 2.73), NS) reduction in odds of a SGA infant with the same adjustment as in urban areas for SGA in the final model (C value=0.766), though it was not significantly associated with odds of giving birth to a SGA infant. Among covariates in model 3, higher maternal height and BMI consistently reduced the odds of a SGA infant in the final model by 16% (0.84, 95% CI (0.79, 0.91), p<0.0001) and

13% (0.87, 95% CI (0.79, 0.96), $p<0.01$) respectively. Increased in blood glucose level was observed to decrease by 21% (0.79, 95% CI (0.63, 0.99), $p<0.05$) the odds of having a SGA infant in the final model only in rural areas (Table 13).

Table 13 Adjusted odds ratio of SGA for maternal insurance in rural areas

	Model 1			Model 2			Model 3		
Variable	ORs	95% CI	P-value	ORs	95% CI	P-value	ORs	95% CI	P-value
Maternal insurance	0.59	(0.13,2.63)	NS	0.56	(0.12,2.55)	NS	0.60	(0.13,2.73)	NS
Age	0.94	(0.88,1.00)	NS	0.99	(0.92,1.06)	NS	1.02	(0.93,1.12)	NS
Height	**0.86***	(0.80,0.92)	<.0001	**0.84***	(0.79,0.91)	<.0001	**0.84***	(0.79,0.91)	<.0001
Education ≥high school	0.82	(0.35,1.93)	NS	0.80	(0.33,1.92)	NS	0.77	(0.31,1.89)	NS
Blood glucose level				0.80	(0.64,1.00)	NS	**0.79***	(0.63,0.99)	<0.05
BMI				**0.86***	(0.79,0.95)	<0.01	**0.87***	(0.79,0.96)	<0.01
Systolic blood pressure				0.99	(0.96,1.02)	NS	0.99	(0.96,1.02)	NS
Multiple pregnancies							1.71	(0.77,3.84)	NS
Parity (Gave birth to a child before)							0.41	(0.15,1.17)	NS
C value		0.711			0.757			0.766	

Note: Mother has no maternal insurance is the reference, mother was primiparous is the reference for parity and multiple pregnancies

* means result reaches statistical significance

4.3.2. LGA

There were 71 LGA infants (29%, out of all the LGA infants) being identified in rural areas. 62 (10.6%) LGA infants were born to mothers without maternal insurance, 9 (21.4%) born to mothers with maternal insurance (Figure 10). Fisher exact test was applied to calculate p-value.

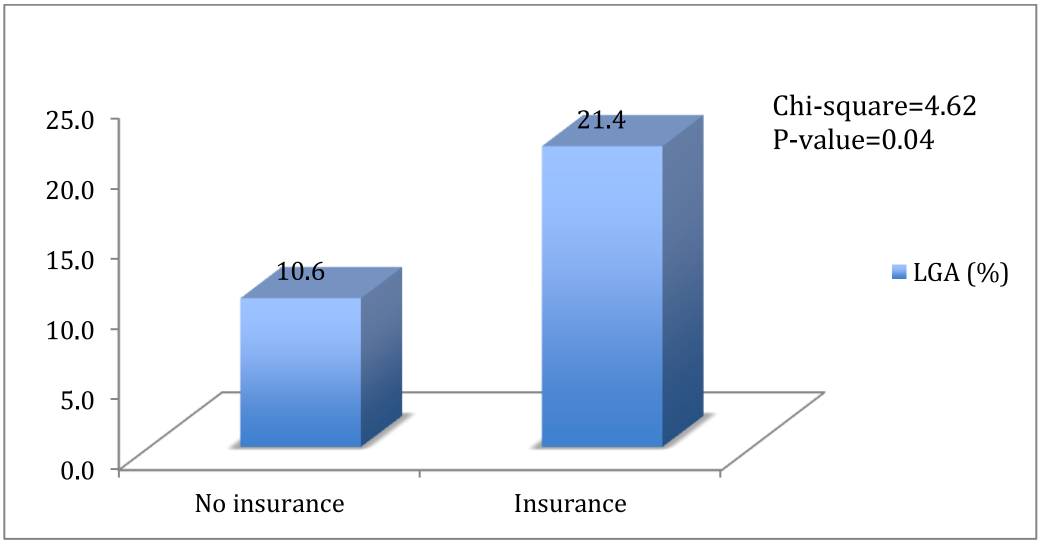

Figure 10 Percentage of LGA by Insurance Status in Rural Areas

Unlike urban areas, having maternal insurance in rural areas was shown to increase 2.16 (95% CI (0.92, 5.04), NS) times the odds of having a LGA infant in model 3 (C value=0.760), although the results did not reach significance. Among covariates in the final model, higher maternal height and BMI increased the odds of delivering a LGA infant by 10% (1.10, 95% CI (1.04, 1.17), p<0.01), and 19% (1.19, 95% CI (1.11, 1.29), p<0.0001), respectively (Table 14).

Table 14 Adjusted odds ratio of LGA for maternal insurance in rural areas									
	Model 1			Model 2			Model 3		
Variable	ORs	95% CI	P-value	ORs	95% CI	P-value	ORs	95% CI	P-value
Maternal insurance	1.95	(0.87,4.38)	NS	2.12	(0.91,4.93)	NS	2.16	(0.92,5.04)	NS
Age	**1.08***	(1.03,1.14)	<0.01	**1.06***	(1.00,1.13)	<0.05	1.04	(0.96,1.12)	NS
Height	**1.08***	(1.02,1.14)	<0.01	**1.10***	(1.04,1.17)	<0.01	**1.10***	(1.04,1.17)	<0.01
Education ≥high school	0.95	(0.46,1.95)	NS	1.02	(0.48,2.15)	NS	1.15	(0.52,2.56)	NS
Blood glucose level				1.04	(0.88,1.23)	NS	1.05	(0.89,1.24)	NS
BMI				**1.20***	(1.11,1.29)	<.0001	**1.19***	(1.11,1.29)	<.0001
Systolic blood pressure				0.97	(0.95,1.00)	NS	0.98	(0.95,1.00)	NS
Multiple pregnancies							1.56	(0.66,3.68)	NS
Parity (Gave birth to a child before)							1.03	(0.39,2.73)	NS
C value		0.664			0.753			0.760	

Note: Mother has no maternal insurance is the reference, mother was primiparous is the reference for parity and multiple pregnancies

* means result reaches statistical significance

4.3.3. Birth Defects

There were 21 infants (44%, out of all the infants with birth defect) born with birth defect (including congenital heart defect) in rural areas. 18 (3.1%) were born to mothers without maternal insurance, 3 (7.1%) born to mothers with maternal insurance (Figure 11). Fisher exact test was applied to calculate p-value.

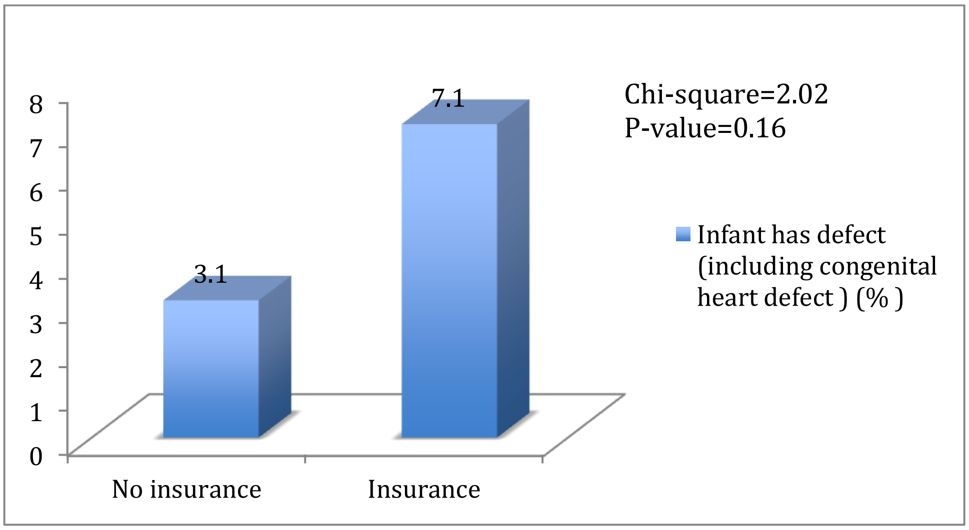

Figure 11 Percentage of Infants Born With Birth Defect (Including Congenital Heart Defect) by Insurance Status in Rural Areas

4.3.4. Congenital Heart Defect

There were 15 (47%, out of all the infants born with congenital heart defect) infants born with congenital heart defect living in rural areas. In the rural areas, 13 (2.3%) were born to mothers without maternal insurance, 2 (4.8%) born to mothers with maternal insurance (Figure 12). Fisher exact test was applied to calculate the p-value.

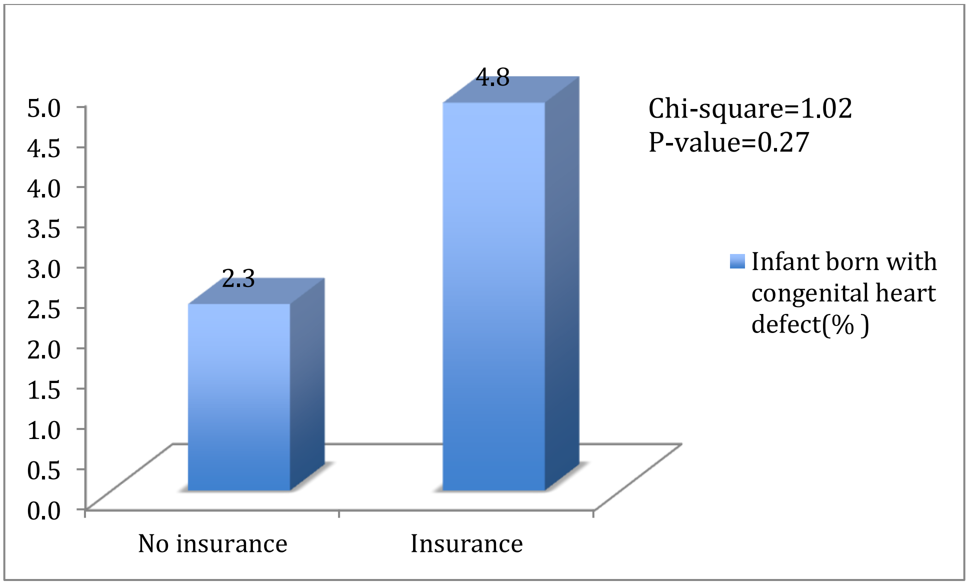

Figure 12 Percentage of Infants Born with Congenital Heart Defect by Insurance Status in Rural Areas

Due to few cases of congenital heart defect, and a small sample of women with maternal insurance, the odds ratios of having an infant born with birth defect or congenital heart defect were only calculated in the first model adjusting for infant's sex. Having maternal insurance, increased the odds of infants born with birth defect 2.48 times (95% CI (0.70, 8.80), NS)), and increased the odds of infants born with congenital heart defect 2.18 times (95% CI (0.48, 10.00), NS)) in rural areas (Table 15-16).

Table 15 Adjusted odds ratio of infant birth defect (including congenital heart defect) for maternal insurance in rural areas

	Model 1		
Variable	ORs	95% CI	P-value
Maternal Insurance	2.48	(0.70,8.80)	NS
Infant's sex as male	1.61	(0.67,3.89)	NS
C value		0.601	

Note: Mother has no maternal insurance is the reference

* means result reaches statistical significance

Table 16 Adjusted odds ratio of infant congenital heart defect for maternal insurance in rural areas

	Model 1		
Variable	ORs	95% CI	P-value
Maternal Insurance	2.18	(0.48,10.00)	NS
Infant's sex as male	1.38	(0.49,3.86)	NS
C value		0.596	

Note: Mother has no maternal insurance is the reference

* means result reaches statistical significance

4.4. Model Evaluation

An internal validation technique of bootstrapping was used to ensure the results generated from the multivariable logistic regression were stable. 1000 replicated bootstrapping samples containing the same observation size with replacement were applied to the final model of independent analysis of residence and joint analysis of maternal insurance and residence. A 95% confidence interval of the 1000 odds ratio, and ROC value for final models' evaluation in each outcome variable, along with parametric method analysis results are displayed in Table 17-20.

Due to the selection method with probability proportional to size with replacement, and a small number of some selected dependent variables, sample selection may include a significant number of samples (more than 2.5% of 1000 samples) that have empty responses for dependent variables, resulting an odds ratio of <0.0001. In such cases, the next smallest odds ratio was chosen as the lower boundary for confidence interval. Because of empty cells, one or more of parameters in the final model of rural areas of the logistic regression could not be estimated.

The non-parametric method bootstrapping results showed a similar odds ratio as the previous parametric method, except for a few differences which were not significant in the previous parametric models, but significant in bootstrapping models.

In the urban areas, blood glucose level decreased the odds of delivering a SGA infant (95% CI (0.81, 0.99)), which reached statistical significance in the final model of the bootstrapping method, but not in parametric method (Table 17).

In rural areas, compared to mothers without maternal insurance, mothers with maternal insurance had significantly higher odds of delivering LGA infants in the final bootstrapping model (95% CI (1.13, 4.37)) (Table 18).

Residence did not have a significant association with SGA, LGA, birth defect or congenital heart defect in the parametric method. But in the final bootstrapping model, compared to rural residence, mothers of urban areas had decreased odds of having infants born with birth defect (95% CI (0.23, 0.89)) or congenital heart defect (95% CI (0.19, 0.91)). Additionally, there were higher odds (95% CI (1.05, 2.99)) of birth defect if the mother had pervious pregnancy in the final non-parametric method, which was not significant in the previous parametric method (Table 19-20). More specific results of residence's independent impact on SGA, LGA and birth defect/congenital heart defect in different models from parametric methods are presented in Appendix II.

Table 17 Bootstrapping results compared to parametric method in final models for SGA

Variable	Residence		Urban Areas		Rural Areas	
	Normal 95% CI	Bootstrapping 95% CI	Normal 95% CI	Bootstrapping 95% CI	Normal 95% CI	Bootstrapping 95% CI
Urban residence	(0.65,1.45)	(0.72,1.38)				
Maternal insurance			(0.85,2.04)	(0.92,1.83)	(0.13,2.73)	(<0.25,1.30)
Age	(0.93,1.03)	(0.93,1.01)	(0.89,1.02)	(0.90,1.00)	(0.93,1.12)	(0.94,1.08)
Height	**(0.89,0.95)***	**(0.90,0.94)***	**(0.91,0.98)***	**(0.92,0.97)***	**(0.79,0.91)***	**(0.79,0.89)***
Education ≥high school	(0.62,1.30)	(0.66,1.20)	(0.59,1.44)	(0.64,1.31)	(0.31,1.89)	(0.29,1.56)
Blood glucose level	**(0.78,0.97)***	**(0.80,0.96)***	(0.78,1.01)	**(0.81,0.99)***	**(0.63,0.99)***	**(0.67,0.95)***
BMI	**(0.84,0.94)***	**(0.85,0.93)***	**(0.84,0.95)***	**(0.85,0.94)***	**(0.79,0.96)***	**(0.78,0.94)***
Systolic blood pressure	(0.99,1.02)	(1.00,1.02)	(0.99,1.03)	(1.00,1.03)	(0.96,1.02)	(0.96,1.01)
Multiple pregnancies	(0.79,1.62)	(0.83,1.46)	(0.70,1.58)	(0.74,1.44)	(0.77,3.84)	(0.65,3.02)
Parity (Gave birth to a child before)	(0.36,1.25)	(0.38,1.04)	(0.27,1.79)	(0.23,1.19)	(0.15,1.17)	(0.19,1.24)
C value	0.668	(0.647,0.703)	0.645	(0.621,0.691)	0.766	(0.723,0.831)

Note: Mother has no maternal insurance is the reference, mother was primiparous is the reference for parity and multiple pregnancies

* means result reaches statistical significance

Table 18 Bootstrapping results compared to parametric method in final models for LGA						
	Residence		Urban Areas		Rural Areas	
Variable	Normal 95% CI	Bootstrapping 95% CI	Normal 95% CI	Bootstrapping 95% CI	Normal 95% CI	Bootstrapping 95% CI
Urban residence	(0.79,1.70)	(0.88,1.60)				
Maternal insurance			(0.62,1.36)	(0.68,1.24)	(0.92,5.04)	**(1.13,4.37)***
Age	(0.99,1.08)	(0.99,1.07)	(0.98,1.10)	(0.99,1.08)	(0.96,1.12)	(0.96,1.10)
Height	**(1.05,1.11)***	**(1.05,1.10)***	**(1.03,1.11)***	**(1.04,1.10)***	**(1.04,1.17)***	**(1.05,1.15)***
Education ≥high school	(0.75,1.52)	(0.82,1.40)	(0.70,1.59)	(0.78,1.49)	(0.52,2.56)	(0.55,2.17)
Blood glucose level	(0.97,1.16)	(0.99,1.12)	(0.94,1.17)	(0.96,1.12)	(0.89,1.24)	(0.93,1.20)
BMI	**(1.11,1.20)***	**(1.12,1.19)***	**(1.09,1.20)***	**(1.10,1.19)***	**(1.11,1.29)***	**(1.13,1.26)***
Systolic blood pressure	(0.98,1.01)	(0.98,1.00)	(0.98,1.02)	(0.99,1.01)	(0.95,1.00)	(0.95,1.00)
Multiple pregnancies	**(1.09,2.17)***	**(1.16,2.00)***	**(1.04,2.23)***	**(1.14,2.08)***	(0.66,3.68)	(0.61,3.07)
Parity (Gave birth to a child before)	(0.73,1.97)	(0.87,1.81)	(0.67,2.26)	(0.80,2.03)	(0.39,2.73)	(0.51,2.86)
C value	0.706	(0.680,0.734)	0.690	(0.663,0.726)	0.760	(0.727,0.810)

Note: Mother has no maternal insurance is the reference, mother was primiparous is the reference for parity and multiple pregnancies

* means result reaches statistical significance

Table 19 Bootstrapping results compared to parametric method in final models for birth defect (including congenital heart defect)

	Residence		Urban Areas	
Variable	Normal 95% CI	Bootstrapping 95% CI	Normal 95% CI	Bootstrapping 95% CI
Urban residence	(0.21,1.01)	**(0.23,0.89)***		
Maternal Insurance			(0.37,2.33)	(0.43,2.13)
Infant's sex as male	(0.63,2.15)	(0.73,2.01)	(0.42,2.09)	(0.49,1.90)
Age	(0.95,1.14)	(0.98,1.14)	(0.88,1.15)	(0.91,1.12)
Education ≥high school	(0.43,1.94)	(0.54,1.83)	(0.42,2.92)	(0.53,3.71)
Height	(0.92,1.05)	(0.93,1.04)	(0.90,1.07)	(0.91,1.04)
Blood glucose level	(0.88,1.30)	(0.92,1.16)	(0.84,1.40)	(0.87,1.21)
BMI	(0.86,1.05)	(0.88,1.03)	(0.83,1.08)	(0.82,1.07)
Systolic blood pressure	(0.98,1.04)	(0.99,1.03)	(0.98,1.06)	(0.99,1.05)
Parity (gave birth to a child before)	(0.17,1.48)	(0.18,1.31)	(0.21,3.55)	(<0,18,2.35)
SGA infant VS Normal infant	(0.20,2.24)	(<0.22,1.37)	(0.19,3.71)	(<0.42,1.86)
LGA infant VS Normal infant	(0.29,2.41)	(0.28,1.57)	(0.31,3.76)	(<0.33,2.32)
Multiple pregnancies	(0.98,3.99)	**(1.05,2.99)***	**(1.20,6.78)***	**(1.40,5.35)***
C value	0.646	(0.621,0.748)	0.675	(0.644,0.809)

Note: Mother has no maternal insurance is the reference, mother was primiparous is the reference for parity and multiple pregnancies

* means result reaches statistical significance

Table 20 Bootstrapping results compared to parametric method in final models for congenital heart defect

Variable	Residence Normal 95% CI	 Bootstrapping 95% CI	Urban Areas Normal 95% CI	 Bootstrapping 95% CI
Urban residence	(0.16,1.12)	**(0.19,0.91)***		
Maternal Insurance			(0.21,1.99)	(0.25,2.06)
Infant's sex as male	(0.35,1.61)	(0.42,1.44)	(0.17,1.37)	(0.16,1.21)
Age	(0.94,1.19)	(0.97,1.18)	(0.90,1.25)	(0.97,1.19)
Education ≥high school	(0.57,4.02)	(0.78,3.75)	(0.69,11.81)	(1.00>15.76)
Height	(0.93,1.10)	(0.94,1.08)	(0.91,1.13)	(0.91,1.12)
Blood glucose level	(0.80,1.31)	(0.83,1.17)	(0.83,1.57)	(0.84,1.41)
BMI	(0.87,1.10)	(0.88,1.08)	(0.82,1.15)	(0.79,1.14)
Systolic blood pressure	(0.98,1.05)	(0.99,1.04)	(0.96,1.06)	(0.97,1.06)
Parity (gave birth to a child before)	(0.24,3.77)	(0.26,2.96)	(0.22,7.29)	(<0.23,5.32)
SGA infant VS Normal infant	(0.35,4.17)	(<0.38,2.75)	(0.33,7.16)	(<0.63,4.02)
LGA infant VS Normal infant	(0.13,2.55)	(<0.31,1.22)	(0.06,3.80)	(<0.40,1.24)
Multiple pregnancies	(0.50,3.23)	(0.51,2.35)	(0.84,7.28)	(0.94,5.45)
C value	0.665	(0.632,0.796)	0.730	(0.698,0.888)

Note: Mother has no maternal insurance is the reference, mother was primiparous is the reference for parity and multiple pregnancies
* means result reaches statistical significance

Chapter 5 Discussions

5.1 Small for gestational age

5.1.1. Residence

Over 70% of women in this study lived in urban areas, and no relationship between maternal residence status and the odds of giving birth to a SGA infant was found. This differed from some previous studies. For instance, the studies from North America have reported that rural residence has lower odds of having a SGA infant (Luo et al., 2010; Luo et al., 2008; Hillemeier et al., 2007), or SGA was not consistently associated with residence across different definitions of residence typologies (Strutz et al., 2012). Based on comparable North American situations, this difference could be explained by two factors. First, the lower odds of SGA in rural areas can be partly explained by the indigenous births in one of the studies (Luo et al., 2010). It is known that First Nations and Inuit women are less likely to have SGA infants, but more likely to have LGA infants, and these populations are clustered in relatively remote rural areas in North America (Auger et al., 2013). Furthermore, Chinese women are considered petit in comparison to Caucasian women, therefore Chinese women tend to have smaller infants than Caucasian women (Wen et al., 1995), but these smaller infants are not considered SGA of a given gestational age based on Chinese population standards. The second factor is the Chinese Huji policy. In this study, urban and rural residence status was not defined as in most studies from North America in literature review using postal code or other methods (Strutz et al.,2012; Luo et al., 2010; Luo et al., 2008), but using Huji, which is a label indicating where one is originally from at the time of birth, and most of the time it remains the same for a Chinese individual’s entire life. Huji represents a Chinese person’s original place of birth, regardless of one’s current living residence. One maintains a rural Huji residence even if one currently lives in urban areas, or moves temporarily from rural to urban for a couple of years and then moves back to rural. Due to fewer job positions, lower salary and disagreeable living conditions in rural areas, urban residents seldom move to rural areas, but people from rural areas may move to urban areas for job opportunities. However, it is usually difficulty for them to change their residence information in Huji. Therefore, even a woman with a rural residence in Huji may be currently living in the urban areas and she would still be labeled as a rural resident, although most women with rural residence in Huji are most likely living in the rural areas. In contrast to Chinese Huji, the most commonly used residence approaches in North America to distinguish urban from rural as Postal code, Census Bureau ZIP code tabulations represent their current residence. The Huji policy in China might be a potential reason for the observed difference.

5.1.2. Maternal Insurance

Approximately 52% participants in this study had maternal insurance, and about 96% of those who had insurance were urban residents. When separated by residence, 68% of women with urban residence had maternal insurance, while only 7% of women with rural residence had maternal insurance. Possession of maternal insurance in urban areas increased the odds of a SGA infant by 1.32 times, but decreased by 40% the odds of a SGA infant in rural areas, though no statistical significance was present. Maternal insurance was deemed not to be associated with the incidence of giving birth to a SGA infant after adjusting selected maternal demographics and physical conditions. This result concurs with one of the previous studies from the United States that specifically stressed the impact of having insurance on SGA, that having health insurance was not associated with the recurrence or incidence of SGA once adjusted for all other maternal demographics and medical conditions (Hinkle et al., 2014). Although several studies from developed countries reported that a lower rate of low birth weight was observed in mothers with health insurance, regardless if it was national public health insurance or commercial health insurance (Hanratty, 1996; Schwartz, 1990). Yet the significant difference regarding the lower rate of low birth weight in insured groups could be attributed to the fact that women with commercial insurance were wealthier compared to other groups (Schwarts, 1990), which might further affect pregnant women's nutritional status due to the accessibility of food (Lee et al., 2013).

In this study, mothers in urban areas with maternal insurance showed a significantly higher rate of primiparity than mothers without maternal insurance, which might be attributed by their higher education. In contrast, mothers in rural areas with maternal insurance had a lower rate of primiparity than mothers without maternal insurance. Literature from England and Korea concur with the fact that primiparous mothers tend to have lighter infants (Alberico et al., 2014; Park et al., 2011). In addition, the authors implied that insured women were employed with a high level of social stress, which could result in delivering SGA infants (Ruwanpathirana & Fernando, 2014). Furthermore, due to Huji registration, some residents labeled as "rural" may be living in urban areas currently. All these factors may complicatedly have multiple levels of impact on the differences of having a SGA infant between urban and rural areas. More researches are needed in China because of the small sample size in rural areas in this study.

5.1.3. Other Factors that Affect Infant SGA

5.1.3.1. Height

The relationship between maternal height and the risk of delivery of a SGA infant observed in this study is similar to other studies (Hinkle et al., 2014). Short maternal stature is associated with increased odds of having a SGA infant regardless of residence status and/or whether mother has a maternal insurance or not.

5.1.3.2. Maternal BMI Measure at GCT Test

There were no other studies investigating maternal BMI measured at GCT test, and its relationship with having a SGA infant. Many previous papers have examined the impact of maternal pre-pregnancy weight status on SGA, and they found that pre-pregnancy BMI classified as overweight or obese was associated with decreased odds of a SGA infant (Li et al., 2013). In this study, it was found that higher maternal BMI measured at 24-28 weeks of gestation was also linked to approximately 11% decreased odds of a SGA infant, and the strength of the odds ratio remained the same in both urban and rural areas accounting for maternal insurance status. Therefore, maternal BMI and its relationship with having a SGA infant supported the current literature accounting for residence and maternal insurance status.

5.1.3.3. Blood Glucose Level Measured at GCT Test

Mothers with higher levels of blood glucose were linked to a decreased risk of having SGA infants regardless of the status of mothers' maternal insurance and/or of their residence. This relationship reached statistical significance in the final model of the parametric method in rural areas, and in the final models of bootstrap method in both urban and rural areas. Two studies have explored the relationship between blood glucose level measured at GCT test, and the odds of having a SGA infant, and both studies have found that women with lower level of blood glucose had higher chances of delivery of SGA infants (Cekmez et al., 2015; Melamed et al., 2013). Similarly, blood glucose level maintained the same impact on having a SGA infant accounting for residence and insurance status.

5.2. Large for Gestational Age

5.2.1. Residence

Residence showed no significant relationship with unhealthy birth weight and birth defects from parametric method in this study. However urban residence showed a significant association with lower odds of birth defects in bootstrap method. Results from previous studies examining over time, the prevalence of extreme LGA for First Nations versus Non-Indigenous populations of Quebec, demonstrated a disparity in LGA infants between Indigenous and non-Indigenous varied by residential community. First Nations births in First Nations communities had a higher prevalence of LGA than First Nations birth in non-indigenous communities, compared to French/English births in non-Indigenous areas (Auger et al., 2013). This finding suggested that living in remote areas might be a risk factor for having a LGA infant, as many First Nations communities are located on reserves. First Nations non-indigenous communities were more likely to be located in more populated regions where access to prenatal care and nutrition were more readily available. Similar study results from Manitoba illustrated that for Non-First Nations, LGA infants were significantly higher in more isolated areas (Luo et al., 2010). However, this study did not show any association in regard to residential status and the risk of having a LGA infant. One of the biggest reasons behind the difference of this study to previous literature is the Huji household registration. The feature of not presenting current residence status from Huji registration added more variability in regard to some rural residents might be currently exposed to urban environment. More reasons of the difference could be explained by the genetic, environmental and culture differences between the First Nations and Chinese. First Nations in North America are usually aboriginals and Inuit people, who are more likely to have LGA infants (Auger et al., 2013). Reserves are known to be small-populated, remote, discontinuous pieces of land with minimal resources and economic opportunities (Keith, 2001). Furthermore, First Nations maintained many cultural traditions in terms of eating habits, seasonal migration, medication and activities (Canadian's first people, 2007).

5.2.2. Maternal Insurance

Similarly, insured populations in urban areas with a higher rate of primiparity would reduce the odds of delivering LGA infants. On the other hand, in urban areas, mothers with maternal insurance were on average older, more educated and wealthier than mothers without maternal insurance, thus they were more likely to spend more time engaging in certain necessary physical exercises suggested by physicians during pregnancy (Gjestland et al., 2013; Clarke & Gross, 2004). A study from the urban areas of Tianjin reported that higher education and habitual exercise before pregnancy significantly increased the odds of pregnant women meeting the recommended physical activities guideline (Zhang et al., 2014). Leisure time moderate physical exercise during pregnancy in mothers, even with gestational diabetes mellitus, may be successful in lowering LGA infants (Mudd et al., 2012; Snapp & Donaldson, 2008). Both explanations lead to a same perception that an urban insured population has less chances of having a LGA infant.

In contrast, mothers in rural areas with maternal insurance had higher chances of delivering LGA infants compared to mothers without maternal insurance. Rural pregnant mothers with maternal insurance tend to be older on average and had significantly less proportion of primiparity in rural areas than pregnant mothers without maternal insurance. Parity is a risk factor for having a LGA infant (Alberico et al., 2014; Park et al., 2011). Additionally, not every rural resident labeled in Huji is currently living in rural areas. However, apart from these factors, there seems to have other variables that are leading rural insured populations to delivering LGA infants, such as insufficient physical exercise during pregnancy. Studies from United State have pointed out that rural pregnant women were less likely to be engaged in certain level of physical exercise during pregnancy (Marshall et al., 2013). Physical activities during pregnancy will be a limitation in this study. Further exploration is still expected.

5.2.3. Other Factors that Affect Infant LGA

5.2.3.1. Height

The relationship between maternal height and risk of delivery of a LGA infant observed in this study is similar to other studies. Previous studies reported that greater maternal height, with or without gestational or pre-gestational diabetes, was associated with a higher rate of LGA (Alberico et al., 2014; Ferraro et al., 2012). Maternal insurance and residence had no impact on the relationship between maternal height and LGA infants.

5.2.3.2. Maternal BMI Measured at GCT Test

In this study, maternal BMI measured at the GCT test as a continuous variable, was linked to an increased rate of LGA in both urban and rural areas with adjustment for maternal insurance status. No other studies were found investigating the association between maternal BMI measured at the GCT test, and risk of having a LGA infant, except for a recent paper that addressed that body mass index measured at GDM screening increased risk of macrosomia using the same dataset (Liu et al., 2014). Nevertheless, literature has indicated evidences of pre-pregnancy BMI classified as overweight, obesity playing a crucial role in delivering extreme high birth weight babies (Alberico et al., 2014; Li et al., 2013; Ferraro et al., 2012), and studies that linked interaction between pre-pregnancy BMI and one hour glucose challenge test results and LGA infants (Subramaniam et al., 2015; Yogev et al., 2005). In this study, higher BMI measured at 24-28 weeks of gestation consistently presented as a risk factor for LGA adjusting for residence and maternal insurance status, which offered another explanation to the existing literature.

5.2.3.3. Multiple Pregnancies

In urban areas, a mother's multiple pregnancies increased the odds of giving birth to a LGA infant by approximately 1.54 times, and such association was not found in rural areas. No previous literature has evidence on multiple pregnancies as a risk for having a LGA infant. However, many studies pointed out that multi-parity was more frequent in mothers who delivered LGA infants, (Jaipaul et al., 2009; Lapunzina et al., 2002) and primiparous mothers tended to have infants that weighted less (Park et al., 2011). China has a unique “one child” family plan policy since 1971 where one family can only have one child as a control for reproduction. Although, families in rural residences can have a second child only if the first child is a girl, and some people choose to pay a penalty to have another child, one child is still the predominant family plan until 2013. The 2010 Chinese national demographic census reported that the national birth rate per family was 1.18, with urban birth rate being 0.88 and rural birth rate being 1.43 (Government of China, 2015f). A new family planning policy came out in 2013 that the family could have a second child if both the parents are only children. The newest family planning policy was officially carried out effective January the first 2016, that every family could have two children in maximum (Government of China, 2015g). As a result, multiparity is not very common in the general Chinese population right now, nor for the past 20 years. Multiple pregnancies instead of parity can better represent Chinese pregnant women's past reproductive exposure, especially in urban areas.

5.3. Birth Defects/Congenital Heart Defect

5.3.1. Residence

Rural residence may affect birth outcomes in several ways, including socioeconomic status, dietary habits, neighborhood conditions and mother's knowledge of the importance of taking multiple supplements during pregnancy, etc. Generally in developing countries of Asia, mothers living in rural areas have lower education, a greater proportion of teenage mothers, poor nutrition intake (Priyali et al., 2007), poor prenatal care, postnatal care, and potential for increased exposure to harmful chemicals (Min et al., 2013; Lu et al., 2010). The results from a study in Inner Mongolia, China, reported that maternal education level is significantly lower in the prevalence of higher birth defects (Zhang et al., 2012). A study from Hungary has also shown that a multivitamin supplement and a folic acid supplement during pregnancy can reduce the occurrence of birth defects or congenital abnormalities (Czeizel, 2004). In rural areas in China, multivitamin supplements may not be widely recommended and accessible to pregnant mothers (Chang, He, & Chen, 2007). Living and working in rural areas may expose mothers to various kinds of agricultural chemicals such as pesticides that people living in urban areas in China are not exposed to (Min et al., 2013; Lu et al., 2010). Maternal agricultural work is known to have an association with birth defects (Heeren & Tyler, 2003). In addition, mothers from China living in urban areas have access to effective use of better care facilities in central urban places (Qi et al., 2012). There are also significant changes in prenatal and postnatal medical care, obstetrical conditions, neonatology practices and effective use of health promotion programs between urban and rural areas in China as have been described in the literature review (Mahmoodi et al., 2013; Bai, & Cui, 2011). Insufficient medical treatment and inadequate prenatal and postnatal care for both mothers and infants in rural areas are due to their difficulty with accessing more advanced hospitals and limited financial income. A study based on data obtained from Gansu province, China, exploring neonatal death between urban and rural, found that Gansu province observed a greater percentage of rural infant deaths taking place out of hospital, and without medical assistance (Bin et al., 2011). Nevertheless, it is still necessary to reiterate that Huji can only represent original place of birth, and some pregnant women labeled as rural residents may have exposed to urban environment currently or for a couple of years before pregnancy. Huji added certain degree of uncertainty as to how many percent of rural residents had certain level of urban exposure.

5.3.2. Maternal Insurance

Similarly, compared to mothers without maternal insurance, the mothers with maternal insurance in urban areas have a significantly higher level of education--education higher than high school (83% versus 45.5%), and a higher rate of being primiparous (95.5% versus 82.3%) or first time pregnancy (69.8% versus 51.9). An education level of less than high school, multiple pregnancies, and parity for a woman have been reported to increase the odds of birth defects (Zhang et al., 2012; Jaipaul et al., 2009). Therefore higher level of education and higher rate of primiparous in urban insured populations had decreased odds of birth defect.

According to the one child policy urban couples can only have one child, while rural couples whose first child is a girl are entitled to have a second child, for a much-coveted male (Government of China, 2015f). Males are important for the rural regions where they are needed for heavy lifting work in the agricultural areas. This phenomenon stems from a fundamental view in the lower education levels in rural areas (Peng, 2012). Lower education and the influence of traditional Chinese perspective of wanting a boy in a family, especially in rural areas, results in frequent accidental or unwanted pregnancy and a great number of female fetuses are terminated through abortion. Abortion itself (Zhang, Olshan, & Cai, 1994) or as a consequence of multiple pregnancies (Zhang et al., 2012) is known for adding more risks for infant birth defects. China and India are the two countries famous for terminating unwanted female fetuses. The London Telegraph estimated that the sex ratio of the Chinese population is 131:100 in favor of males. There are nearly 750,000 more males than females born in China every year (Female Infanticide in India and China, 2012). Unwanted pregnancy and the induced abortion may partly explain why in rural areas insured populations had higher rate of birth defect.

In a literature review by the government of China (2015c), pregnant women who have maternal insurance are currently employed. However, the rural female population generally have a very low education level, combined with maternal insurance status, which indicate employment status, but the employment may be an indication that they are working in dangerous mining, construction, or manufacture industries, places that are known for heavy physical lifting, contact with unsafe chemicals and high social stress (Palgrave et al., 2009). These risk factors combined with rural residence may place these pregnant women into a higher risk for their infants to be born with a birth defect.

5.4. Limitations

5.4.1. No Information on Potential Mediators

The analysis of this study was based on secondary data, and the dataset didn't have some potential variables related to infant unhealthy birth weight and birth defects that could address the observed differences. The potential variables include maternal alcohol consumption (Zhang et al., 2012; O'Leary et al., 2010), activity during pregnancy (Marshall st al., 2013; Mudd et al., 2012; Snapp & Donaldson, 2008), excessive gestational weight gain (Li et al., 2013; Ferraro et al., 2012), maternal smoking during pregnancy (Patel & Burns, 2013 ;Tikellis et al., 2012) and family heredity (Oyen et al., 2009; Harlap et al., 2008).

5.4.2 Huji Residence

Residence status based on Huji household registration was actually another limitation because Huji residence may not accurately reflect participants' rural –urban status currently. If the current information on living location had been collected at the time of the study, the result might have been different.

5.4.3. External Validity

China has a one child policy and Huji household registration, which are very unique policies in the world. Residence in this study was based on Huji registration, and the one child policy is interactively correlated with people's residence and insurance status. Therefore, the results of this study may not be applicable to other countries. However, like China, India may be similar in certain situations, such as the health care system and urban–rural disparity; in addition, both are large countries. The results from this study might be observed in India as well. Further studies are still needed to examine the effect of maternal insurance and residence status on perinatal outcomes in other countries.

5.5. Strengths

The data was collected from a large population- dataset. Tianjin is a large city, and the Beichen district has a population density of both urban and rural residents, and different socioeconomic status groups with good representation of the general Chinese population. The results of this study may be generalized to other provinces or other cities of China. This is the first study examining the impact of maternal insurance on selected perinatal outcomes within the Chinese population. It is also the first study to explore the effect of maternal insurance and residence in its relation to birth outcomes worldwide. The study examined the effect of maternal insurance and residence in different models to compare their contributions to birth outcomes, while other studies have examined the independent influence of either maternal insurance only or residence only, but not the both. Using Huji other than the commonly used methods to determine women's residence status is unique. The residence in this study may reflect the woman's original place of birth, possible upbringing level, and/or current environmental exposures; this may differ from the existing literature in which "residence" is usually to reflect where the woman is currently living.

5.6. Conclusions

Unhealthy birth weight and birth defects are adverse birth outcomes that affect infants both in the short- and the long-term, and may even lead to death if proper treatment has not been administered. Pregnant women and infants more than anyone in society need to be protected and supported with adequate prenatal and postnatal health care, and better living conditions. Apart from the known risk factors for adverse perinatal outcomes, research focus was given to maternal socioeconomic factors –maternal insurance and residence status, especially their effect on selected perinatal outcomes. Results from this study demonstrate that whether having maternal insurance did have an impact on perinatal outcomes, but the impact of maternal insurance on the perinatal outcomes showed differently between women with urban residence and women with rural residence status. However, it is not clear what are the reason causing the observed differences. Additionally, due to the special policies of Huji, and the new policy of family planning in China recently, more studies are definitely needed.

Future studies should pay more attention on collecting additional information on the missing potential mediators of this study, especially maternal smoking during pregnancy and second hand smoking exposure because smoking during pregnancy is a major indicator for SGA babies. Furthermore, the information of the participants' current residence should be collected and be used to examine which definition is more associated with the perinatal outcomes.

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Appendix I Sample size change for exclusion criteria

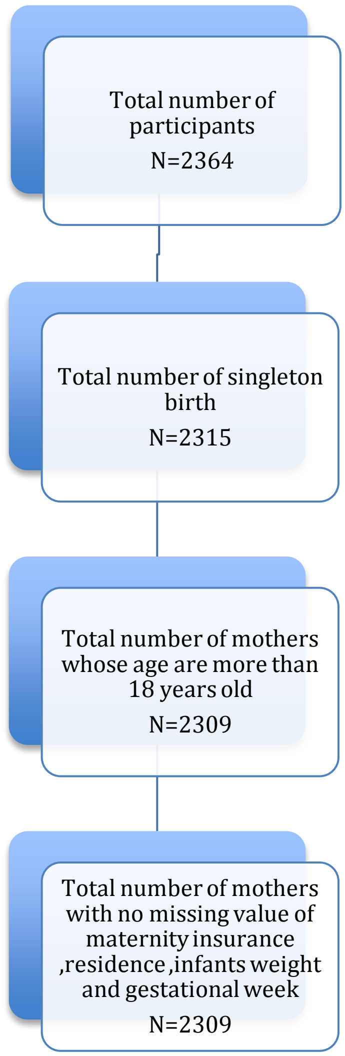

Figure A1 Sample size change for exclusion criteria

Appendix II Results of adjusted odds ratios of perinatal outcomes for residence

Table A1 Adjusted odds ratios of SGA for residence

	Model 1			Model 2			Model 3		
Variable	ORs	95% CI	P-value	ORs	95% CI	P-value	ORs	95% CI	P-value
Urban residence	1.14	(0.78,1.65)	NS	1.04	(0.71,1.53)	NS	0.97	(0.65,1.45)	NS
Age	**0.93***	(0.89,0.97)	<0.001	0.97	(0.92,1.01)	NS	0.98	(0.93,1.03)	NS
Height	**0.92***	(0.90,0.95)	<.0001	**0.92***	(0.89,0.95)	<.0001	**0.92***	(0.89,0.95)	<.0001
Education ≥high school	0.99	(0.72,1.38)	NS	0.94	(0.66,1.33)	NS	0.90	(0.62,1.30)	NS
Blood glucose level				**0.87***	(0.78,0.97)	<0.01	**0.87***	(0.78,0.97)	<0.05
BMI				**0.89***	(0.84,0.93)	<.0001	**0.89***	(0.84,0.94)	<.0001
Systolic blood pressure				1.01	(0.99,1.02)	NS	1.01	(0.99,1.02)	NS
Multiple pregnancies							1.13	(0.79,1.62)	NS
Parity (Gave birth to a child before)							0.67	(0.36,1.25)	NS
C value		0.629			0.667			0.668	

Note: mother was primiparous is the reference for parity and multiple pregnancies

* means result reaches statistical significance

Table A2 Adjusted odds ratios of LGA for residence

	Model 1			Model 2			Model 3		
Variable	ORs	95% CI	P-value	ORs	95% CI	P-value	ORs	95% CI	P-value
Urban residence	0.99	(0.70,1.39)	NS	1.06	(0.74,1.52)	NS	1.16	(0.79,1.70)	NS
Age	**1.08***	(1.04,1.12)	<.0001	**1.06***	(1.02,1.10)	<0.01	1.03	(0.99,1.08)	NS
Height	**1.07***	(1.04,1.10)	<.0001	**1.08***	(1.05,1.11)	<.0001	**1.08***	(1.05,1.11)	<.0001
Education ≥high school	0.82	(0.60,1.12)	NS	0.91	(0.66,1.26)	NS	1.07	(0.75,1.52)	NS
Blood glucose level				1.05	(0.96,1.15)	NS	1.06	(0.97,1.16)	NS
BMI				**1.16***	(1.11,1.21)	<.0001	**1.16***	(1.11,1.20)	<.0001
Systolic blood pressure				0.99	(0.98,1.01)	NS	0.99	(0.98,1.01)	NS
Multiple pregnancies							**1.54***	(1.09,2.17)	<0.05
Parity (Gave birth to a child before)							1.20	(0.73,1.97)	NS
C value		0.608			0.696			0.706	

Note: mother was primiparous is the reference for parity and multiple pregnancies

* means result reaches statistical significance

Table A3 Adjusted odds ratios of infant birth defect (including congenital heart defect) for residence

	Model 1			Model 2			Model 3			Model 4			Model 5		
Variable	ORs	95% CI	P	ORs	95% CI	P	ORs	95% CI	P	ORs	95% CI	P	ORs	95% CI	P
Urban residence	**0.47***	(0.26,0.84)	<0.05	0.57	(0.28,1.15)	NS	0.53	(0.25,1.10)	NS	0.49	(0.23,1.06)	NS	0.46	(0.21,1.01)	NS
Infant's sex as male	1.11	(0.62,1.96)	NS	1.07	(0.59,1.94)	NS	1.17	(0.64,2.16)	NS	1.17	(0.63,2.15)	NS	1.17	(0.63,2.15)	NS
Age				1.04	(0.97,1.12)	NS	1.03	(0.96,1.12)	NS	1.05	(0.96,1.15)	NS	1.04	(0.95,1.14)	NS
Education ≥high school				0.86	(0.43,1.73)	NS	0.90	(0.44,1.86)	NS	0.84	(0.40,1.77)	NS	0.92	(0.43,1.94)	NS
Height							0.99	(0.93,1.05)	NS	0.99	(0.92,1.05)	NS	0.98	(0.92,1.05)	NS
Blood glucose level							1.08	(0.89,1.30)	NS	1.07	(0.88,1.30)	NS	1.07	(0.88,1.30)	NS
BMI							0.95	(0.87,1.04)	NS	0.95	(0.86,1.05)	NS	0.95	(0.86,1.05)	NS
Systolic blood pressure							1.01	(0.99,1.04)	NS	1.01	(0.98,1.04)	NS	1.01	(0.98,1.04)	NS
Parity (gave birth to a child before)										0.72	(0.25,2.05)	NS	0.50	(0.17,1.48)	NS
SGA infant VS Normal infant										0.68	(0.20,2.28)	NS	0.67	(0.20,2.24)	NS
LGA infant VS Normal infant										0.86	(0.30,2.51)	NS	0.83	(0.29,2.41)	NS
Multiple pregnancies													1.98	(0.98,3.99)	NS
C value		0.582			0.599			0.619			0.622			0.646	

Note: mother was primiparous is the reference for parity and multiple pregnancies

* means result reaches statistical significance

Table A4 Adjusted odds ratio of infant congenital heart defect for residence

	Model 1			Model 2			Model 3			Model 4			Model 5		
Variable	ORs	95% CI	P	ORs	95% CI	P	ORs	95% CI	P	ORs	95% CI	P	ORs	95% CI	P
Urban residence	**0.43***	(0.21,0.86)	<0.05	0.40	(0.16,1.01)	NS	0.42	(0.17,1.04)	NS	0.43	(0.16,1.14)	NS	0.42	(0.16,1.12)	NS
Infant's sex as male	0.79	(0.39,1.60)	NS	0.72	(0.34,1.52)	NS	0.76	(0.35,1.62)	NS	0.75	(0.35,1.61)	NS	0.75	(0.35,1.61)	NS
Age				1.06	(0.97,1.16)	NS	1.06	(0.97,1.17)	NS	1.06	(0.95,1.19)	NS	1.06	(0.94,1.19)	NS
Education ≥high school				1.52	(0.61,3.77)	NS	1.45	(0.57,3.65)	NS	1.47	(0.55,3.91)	NS	1.51	(0.57,4.02)	NS
Height							1.01	(0.93,1.09)	NS	1.01	(0.93,1.10)	NS	1.01	(0.93,1.10)	NS
Blood glucose level							1.02	(0.80,1.30)	NS	1.02	(0.80,1.31)	NS	1.02	(0.80,1.31)	NS
BMI							0.97	(0.87,1.09)	NS	0.98	(0.87,1.10)	NS	0.98	(0.87,1.10)	NS
Systolic blood pressure							1.02	(0.98,1.05)	NS	1.02	(0.98,1.05)	NS	1.01	(0.98,1.05)	NS
Parity (gave birth to a child before)										1.09	(0.30,3.96)	NS	0.95	(0.24,3.77)	NS
SGA infant VS Normal infant										1.22	(0.35,4.21)	NS	1.21	(0.35,4.17)	NS
LGA infant VS Normal infant										0.59	(0.13,2.58)	NS	0.58	(0.13,2.55)	NS
Multiple pregnancies													1.27	(0.50,3.23)	NS
C value		0.629			0.635			0.651			0.666			0.665	

Note: mother was primiparous is the reference for parity and multiple pregnancies

* means result reaches statistical significance